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THE

WORKS

OF

FRANCIS BACON,

BARON VERULAM, VISCOUNT ST. ALBAN, AND LORD HIGH CHANCELLOR OF ENGLAND.

VOLUME THE NINTH.

CONTAINING

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SYLVA SYLVARUM.

PAINTING THE BODY.

THE Turks have a black powder, made of a mineral called alcohole, which, with a fine pencil, they lay under their eye-lids, so as to colour them black, whereby the white of the eye is set off whiter. With the same powder they colour also the hairs of their eye-lids, and eye-brows, which they draw into arches. And Xenophon relates, that the Medes used to paint their eyes. The Turks, with the same tincture, black the hair of their heads and beards. And many with us, who are grown grey, and yet would appear young, make their hair black, by combing it with a leaden comb, or the like.* The Chinese, who

* But a much better way, for this purpose, is to use the common solution of silver, well diluted with water; which appears to be the preparation, sold in London, for turning red or other coloured hair to a beautiful brown or black.

are olive-coloured, paint their cheeks scarlet, especially the emperor and grandees. Generally barbarous people, that go naked, not only paint themselves, but pounce and raise their skin, so that the painting cannot be taken out, and make it into works.* So do the West Indians, and so did the ancient Picts and Britons; whence it seems that men would have the colour of birds' feathers if they could, or at least gay skins instead of gay clothes.

PASSIONS.

THE passions of the mind make the following impressions upon the body: fear causes, 1. paleness, 2. trembling, 3. erection of the hair, 4. starting, and 5. shrieking. The paleness proceeds hence, that the blood runs towards the centre, to succour the heart; the trembling hence, that by the flight of the spirits inwards, the external parts are deserted and forsaken; erection of the hair is caused by the closing of the pores of the skin, whence the hair that before lay aslope must needs rise. Starting is both an apprehension of the thing feared, and an enquiry in the beginning what the matter should

* This is frequently practised, by pricking holes in the skin with a needle, and rubbing pulverized gunpowder upon the part.

be, whence it is both a motion of shrinking and a motion of erection; therefore when a man would listen suddenly to any thing, he starts, for the starting is an erection of the spirits to attend. Shrieking is an appetite of expelling that which suddenly strikes the spirits; for many motions, though unable to expel what is hurtful, are yet offers of nature, and cause motions by consent, as in groaning, or crying out, upon pain.*

Grief and pain cause 1. sighing, 2. sobbing, 3. groaning, 4. screaming, 5. roaring, 6. tears, 7. distortion of the face, 8. grinding of the teeth, and 9. sweating. Sighing is caused by drawing in a greater quantity of breath, to refresh the heart that labours, like taking a large draught when one is thirsty. Sobbing is the same thing, but stronger. Groaning, screaming, and roaring are caused by an appetite of expulsion; for when the spirits cannot expel the offending subject in striving to do it by the motion of consent, they expel the voice, and this happens when the spirits yield, and cease to resist; for if we constantly resisted pain, we should not groan. Tears are caused by a contraction of the spirits of the brain, constringing the moisture thereof, whence tears are sent into the eyes; and this contracti-

* It is worth observing how close and strong the foundations are here laid for a philosophical history of the passions.

on or compression causes also wringing of the hands; for wringing is a gesture of expressing moisture. The distortion of the face is caused by a struggle, first, to bear and resist, and then to expel, which makes the parts first knit, and afterwards open. Grinding of the teeth is likewise caused by collecting the spirits to resist, which makes the teeth also set hard one against another. Sweating also is a compound motion from the labour of the spirits, first to resist and then to expel.

Joy causes, 1. a chearfulness and vigour in the eyes; 2. singing, leaping, dancing, and sometimes tears: all these are the effects of the dilatation and eruption of the spirits into the external parts, which makes them more lively and brisk. Excessive sudden joy has caused present death; while the spirits diffused themselves so much, they could not retreat again. Tears are the effects of compressing the lachrymal glands, upon the dilatation of the spirits: for compression of the spirits causes an expression of the moisture of the eyes by consent, as in grief; but in joy, it works by propelling the moisture, when the spirits dilate, and occupy more room.*

* See Boerhaave's Institutiones Medicæ, page 278. De Voce, Loquelo, Cantu, Risu, &c.

Anger causes, 1. Paleness in some, and the going of the colour in others; also, 2. trembling; 3. swelling; 4. foaming at the mouth; 5. stamping with the feet, and bending of the fist. Paleness and the going and coming of the colour are caused by the heat of the spirits about the heart, which, to refresh themselves, call in more spirits from the outward parts. And if the paleness be alone, without sending forth the colour again, it is commonly joined with some fear; but in many there is no paleness at all, only a redness about the cheek, which arises from sending forth the spirits in an appetite of revenge. Trembling, in anger, proceeds likewise from a calling in of the spirits, and happens commonly when anger is joined with fear. Swelling proceeds from a dilatation of the spirits by over-heating; and from a liquification, or boiling of the humours thereupon. Foaming at the mouth proceeds from the same cause, being an ebullition. And stamping, and clenching of the fist, proceeds from an imagination of the act of revenge.

Light displeasure or dislike causes, 1. shaking of the head; 2. frowning, and knitting of the brows. These effects arise from the same causes as trembling and horror, viz. the retiring of the spirits, but in a less degree: for, the shaking of the head is but a slow and definite trembling, and

a gesture of slight refusal; we see also that dislike often causes that gesture of the hand we use upon refusing a thing, or warning it away. The frowning and knitting of the brows is a gathering of the spirits to resist in some measure; and knitting of the brows follows upon earnest thought of any thing, though it be without dislike.

Shame causes 1. blushing; and 2. a down-cast look. Blushing is the resort of blood to the face, which, in the passion of shame, is the part that labours most; and though blushing will appear in the whole breast, if naked, yet it is but in passage to the face. The down-cast of the eyes preceeds from the reverence a man bears to others; so that, when he is ashamed, he cannot endure to look stedfastly upon them: and both blushing and the casting-down of the eyes, are greater when we appear before a number, and likewise when we come before great or reverend persons.*

Pity sometimes causes 1. tears, and 2. a side cast of the eye: tears here come from the same cause they do in grief; for pity is but grief in another's behalf. The side-cast of the eye is a gesture of aversion, or an unwillingness to behold the object of pity.

* Ore Pompeii quid mollius? Nunquam enim non coram pluribus erubuit.

Wonder causes, 1. astonishment, or an immoveable posture of the body; 2. casting up of the eyes, and lifting up of the hands. Astonishment is caused by fixing the mind upon one object of thought, whence it does not expatiate as usual; for, in wonder, the spirits fly not, as in fear, but only settle, and become less apt to move. Casting up of the eyes and lifting up of the hands is a kind of appeal to the Deity, or the author, by his power and providence, of great wonders.

Laughing causes a dilatation of the mouth and lips; a continual expulsion of the breath, with a loud noise, which makes the interjection of laughter; and, if violent and continued, shaking of the breast and sides, and running of the eyes with water. Laughing can scarce be called a passion, as having its source from the intellect; for, in laughing, there always precedes a conceit of somewhat ridiculous, and therefore is proper to man. The cause of laughing is but a light touch of the spirits, and not so deep an impression as in other passions; whence it may be excited, and that in great violence, barely by tickling some parts of the body; and men, even in a grieved state of mind, cannot sometimes forbear laughing. It is always joined with some degree of delight, and therefore has an affinity with joy, though it be a much lighter

motion.* Its objects are deformity, absurdity, a witty turn, or the like.

As to the causes of the effects before-mentioned, viz. the dilatation of the mouth and lips, the continued expulsion of the breath and voice, and the shaking of the breast and sides, they all proceed from the sudden dilatation of the spirits. Suddenness has here a great share; for any shrewd turn that lights upon another, or any deformity, &c. moves laughter in an instant, which, after a little time, it does not; thus we cannot laugh at a stale jest, but only while it is new. And even in tickling, if you tickle the sides, and give warning, or give a hard and continued touch, it does not move laughter so much.

Lust occasions a flagrancy in the eyes, and a priapism. The cause is, that in lust, the sight and touch are the things desired, and therefore the spirits resort to those parts which are most affected. And note, in general, that the spirits, in all passions, resort most to the parts that labour most, or are most affected, as, in the last mentioned, they resort to the eyes and parts of generation; in fear and anger, to the heart; in shame, to the face; and in slight dislikes, to the head.†

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* Res severa est verum gaudium.

† The author has many things relating to the history of the

PENETRATION.

THE emptiness of several bodies, and their appetite to take in others, is a deep consideration. Air takes in light, sounds, smells, and vapours with a kind of thirst, as not satisfied with its own consistence, else it would never receive them so suddenly and easily. Water and all liquors take up dry and terrestrial bodies; and dry bodies drink in waters and liquors, that one is a glue to the other. Parchments, skins, cloth, &c. drink in liquors, though themselves are entire bodies, and not comminuted, as sand and ashes are, nor apparently porous. Metals themselves readily receive the aquæ fortes, and the aquæ fortes readily penetrate into metals and stones. That menstruum will touch gold, which will not touch silver, and vice versa. Nay gold, which seems to be the closest and most solid body in nature, greedily drinks in quicksilver. And it seems that this reception of other bodies is not violent, for it is often reciprocal, and, as it were, with consent. Of the cause hereof, and to what axiom it may be referred, consider

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passions in his Sapientia Veterum and Moral Essays. See also the De Augmentis Scientiarum, Sect. II. or the fable of Bacchus. And again, Sect. XX. and XXI. of ethics, &c. Consult likewise Mr. Hutchinson's late Discourse of the Passions.

attentively.* For the quaint assertion, that "Matter, like a common strumpet, covets all forms," is but a roving notion. Flame alone, takes in no other body; but either overcomes or turns other bodies into it, as by conquest; or dies, and goes out itself.† See the articles, *Nature*, *Spirits*, and *Sympathy*.

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* The vulgar physics scarce take notice of any such thing as that here mentioned; though it may deservedly seem to constitute the very essence of natural philosophy; as shewing by what particular powers, and principles, all material things are separated, and held together. Certainly the doctrine of menstruums, which has hitherto been chiefly confined to a few chemical operations, should be set free, and extended to all natural bodies; so as to discover the laws of their cohesion, union, separation, mixture, and conversion; or the whole process of nature, in conserving and repairing, and changing the bodies of the universe: the physical causes whereof will probably be found to be numerous particular laws of attraction and repulsion; as, for want of more precise and accurate notions, we are obliged to call them. And if, at length, the whole of this comprehensive doctrine can be reduced to an axiom; might not that axiom contain the true, physical, or efficient cause of the various forms and appearances of bodies? But this is anticipating too much; unless it were to intimate what discoveries are still behind; and might be rationally expected, if the author's method of enquiry were diligently pursued.

† This subject highly deserves a vigorous prosecution: and by way of opening to the enquiry, it might be proper to consult the Chapter of Menstruums in Boerhaave's Chemis-

*. The Philosophical Transactions, the French Memoirs,

PERCOLATION.

It is observed in some parts of Africa, that after a time, the water in pits, dug on the sea-shore, will grow brackish again. For at length the very sand, through which the salt-water passes, becomes saline; and so the strainer itself is infected. The remedy therefore is, to dig new pits when the old grow brackish; and thus change the strainer.

If a pit be sunk upon the sea-shore, deeper than the low-water mark; but with its mouth somewhat above the high-water mark; as the tide comes in, the pit will fill with water, fresh and potable. This is commonly practised upon the coast of Barbary; where other fresh water is wanting. The thing was also put in practice by Cæsar, who when besieged in Alexandria, having the sea-water turned upon the wells; thus saved his army in despair. But Cæsar mistook the cause, in supposing that all sea-sands had natural springs of fresh water; for the pit here fills, as the tide rises.

Salt water has been passed through earth, and ten vessels, one within another; yet without

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Mr. Boyle, Dr. Hook, and Sir Isaac Newton, afford some hints to this purpose; especially with regard to the conversion of bodies into light, and light into bodies, &c.

losing its saltness, so as to become potable: but salt-water, strained through a greater number of vessels, has become fresh: which experiment seems to cross that other of pits, though but in part; if it be true, that more repetitions do the thing. *

It is here worth nothing, what poor imitations are made of nature, in the common course of experiments; unless conducted by judgment, and some good light of axioms.† For first, there is a great difference between passing water through many small vessels; and through such a space, as between low-water, and high-water mark. Secondly, there is a great difference between earth, and sand; for all earth holds a kind of nitrous salt, ‡ from which sand is free. Besides, earth does not strain the water so fine as

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* This method of percolation per ascensum, though so large a bed of sand as the difference betwixt low and high water mark, is impracticable at sea; whence certain precipitations, and distillations, have been proposed for sweetening salt-water in long voyages: but these methods also seem deficient in point of commodiousness and practicability. If the thing be greatly wanted, men might perhaps do well to have their eyes upon artificial congelation; and the ways of procuring it in any time of the year.

† See the Novum Organum, Part II. Sect. I.

‡ Has this salt been obtained, from all earths, by washing, boiling, and the common process for crystallization?

sand. Lastly, in transmitting the sea-water into pits, the water rises; but in the transmission of it through vessels, it falls. Now the salter part of water goes to the bottom: and, therefore, no wonder if the straining of sea-water by descent, should not make it fresh. Again, the very dashing of the water, if it comes from the sea, is more proper to strike off the salt part, than when the water slides of its own motion.*

Percolation seems a good kind of separation; not only of thick from thin, and gross from fine; but of more subtile natures. It also varies according to the body through which it is made; thus, through woollen, the liquor leaves its fatness behind;† through sand, its saltness, &c.

The clear gum of trees, is but a certain juice of the tree, finely strained through the wood and bark. In like manner, Cornish-diamonds, and rock-rubies, are the fine exudations of stone.

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* These particulars deserve to be attentively considered; to shew their justness, and lead to farther discoveries, with relation to the sweetening of sea-water; and other operations.

† Thus in distilling from malt-wash, as they call it, a thick woollen strainer separates a large quantity of fulsome unctuous matter, that would otherwise render the spirit nauseous and fetid.

The feathers of birds are of more lively colours, than the hairs of beast; for no beast has any fine azure, or carnation hair. Aristotle gives this reason for it; that birds are more in the sun, than beasts; which is manifestly false: for cattle are more in the sun than birds, that commonly live in covert. The true cause may be, that the excrementitious moisture of living creatures, which makes as well the feathers in birds, as the hair in beasts, passes in birds thro' a more delicate strainer, than in beasts: for feathers pass through quills; and hair, through skin.

The clarifying of liquors by adhesion, is an inward percolation,* and effected, when some cleaving body is mixed and agitated with liquors; whereby the grosser part sticks to that cleaving body: whence the finer are freed from the grosser. So the apothecaries clarify their syrups by whites of eggs; which gather all the dregs, and grosser parts of the juices to them: and the syrup being set on the fire, the whites themselves harden, and are taken off. So ippocrass is clarified by mixing it with milk; stir-

* Where the strainer passes through the body of the liquor, carrying down the grosser parts along with it, as in a net.

ring it about, and then passing it through a woollen bag: the cleaving nature of the milk, drawing the powder of the spices, and grosser parts of the liquor to it; so that in the passage they stick to the woollen bag.

The clarifying of water, is an experiment tending to health; besides the pleasure of the eye, when water appears crystalline. This is effected by placing pebbles at the head of the current; that the water may strain through them.*

Perhaps, percolation not only causes clearness and splendour, but also sweetness of odour; for this follows as well as clearness, when the finer parts are separated from the grosser. So the sweat of men, who have much heat, much exercise, clean bodies, and fine skins, smells sweet; as was said of Alexander; and we commonly find that gums are odoriferous.† See the articles, *Clarification*, *Drinks*, *Salt-Water*, and *Separation*.

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* It is common in Italy and Holland to use filtering-stones, cut into a kind of mortars, for clarifying water; and some have them also in England. See the article *Clarification*.

† This observation might be also extended to tastes: thus wines, &c. taste much finer for being clarified. And whoever shall prosecute this enquiry of percolation, in a variety of subjects, may doubtless discover many considerable things with regard to refinements. Thus in particular, this

PILOSITY.

BEASTS are more hairy than men, and savages more than the civilized: but the plumage of birds exceeds the pilosity of beasts. The cause of greater smoothness in men is not any great heat and moisture, though that indeed may occasion pilosity; but there is requisite to pilosity, not direct heat and moisture, so much as excrementitious heat and moisture: for whatever assimilates, goes not into the hair: and excrementitious moisture abounds most in beasts, and savages. The plumage of birds has much the same cause; for birds assimilate less, and discharge more than beasts: their excrements being liquid, and their flesh generally more dry. Besides, they have no organs of urine; so that all their excrementitious moisture goes into the feathers: whence it is no wonder, birds should commonly be better meat than beasts, because their flesh assimilates finer, and secretes more subtilly. Again, the head of a man is hairy at his birth; which no other part of the body is. The cause may be want of perspiration; for much of the matter of hair, in other parts of

refinement of borax, which has proved a very gainful business to some, depends upon a proper percolation. So does the refining of sugar, manna, tartar, and numerous drugs.

the body, goes off by insensible perspiration. Besides, the skull being of a more solid substance, nourishes and assimilates less, and excerns more; so likewise does the skin. We see also, that hair comes not upon the palms of the hands, nor the soles of the feet; which are parts more perspirable: and children are not hairy; because their skins are more perspirable. *

PLAGUE.

During the late plague, there were found in several ditches, and low grounds about London, many toads, that had tails, two or three inches long; whereas toads usually have no tails at all. This shewed a great disposition in the soil and air, to putrefaction. It is reported likewise, that roots, as carrots and parsnips, are more sweet and luscious in infectious years than ordinary.†

* This article has relation to a physical anatomy, which seems scarce hitherto begun; I mean the investigation of the physical causes of the phenomena of animal bodies. For the causes hitherto assigned in anatomy are rather final than physical; and have a greater regard to the remote wisdom, and contrivance, shewn in the structure of the parts, than the direct, and immediate manner of their formation; or the true process and operation of nature used therein.

† The same has been said of fruits, as cherries, &c. and it is usual in infectious seasons, for the multitude to accuse

Those years have been noted for pestilential, and unwholesome, wherein there were great numbers of frogs, flies, locusts, &c. For these creatures being engendered of putrefaction; an abundance of them shew a general disposition of the year, and constitution of the air, to diseases, that proceed from putrefaction.*

The plague is often said to be catched without any manifest indication; and they report, where it is found, that it has the scent of a mellow apple, or of May-flowers. It is also received, that the smell of flowers, ripe and luscious, are bad in the plague; such as white lilies, cowslips, and hyacinths.

The plague is not easily received by those that continually attend the sick; as physicians, &c. nor by such as take antidotes; viz. mithridate, juniper-berries, rue; or hold in the mouth, angelica, zeodary, &c. or use tar, galbanum, and the like, in perfumes; nor again by old people, and such as are of a dry and cold complexion.

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some one thing or other; but with what justness is not so certain.

* Does the plague proceed from direct putrefaction; or some more latent cause? To determine this, so as to form axioms, and sure rules of practice, requires a rigid enquiry; which seems hitherto scarce attempted. For they are generally but crude observations, jejune experiments, and superficial notions, that have been published upon this subject.

On the other hand; the plague soonest seizes those that come out of the fresh air; those that are fasting; and children. It is likewise noted to go in a blood, more than from stranger to stranger.*

POISONS.

THE most pernicious infection, next the plague, is that of a jail; where prisoners have been long kept close, and unwholesome. Of this we have had experience, twice or thrice, in my time; when the judges, and many of the attendants, sickened upon it, and died. It were therefore prudent in such cases to air the prison, before the prisoners are brought out.

If such destructive smells may be made by art, they must, probably, consist chiefly of man's flesh, or putrefied sweat;† for those ill

* These particulars seem remarkably confirmed by Diemerbroeck's Account of the Plague at Nimwegen. See also Mr. Boyle's Treatise of Effluvia; and the articles *Air* and *Poisons*.

† What certainty is there in these conjectures? It is indeed said to this day, that the most destructive poisons of the Indians are prepared from man's flesh; which, to have any such effect, must probably be putrefied; and used in the height of the putrefaction. We know that putrefied eggs, and animal juices, have a poisonous quality; and might, perhaps, prove mortal, barely by the smell. See the Processes upon Animals, in Boerhaave's Chemistry.

odours which the nostrils immediately abhor and expel, are not the most pernicious; but such as have some similitude with the body; so that they imperceptibly insinuate themselves, and betray the spirits.

There may be great danger in using such compositions at large meetings of people, within doors; as in churches, at arraignments, at plays, solemnities, and the like: for poisoning of air is no less dangerous, than poisoning of water; which was practised by the Turks in the wars; and by Emmanuel Comnenus upon the christians, when they passed through his country to the Holy Land. And this poisoning of air is the more dangerous in concourses of people, because their breath promotes the reception of the infection; and therefore when any such thing is suspected, those public places should be perfumed before the assemblies meet.

The poisoning of particular persons by odours, has been practised in perfumed gloves, or the like: and probably they mix the poison with some sweet smells, which also make it the sooner received. Plagues too have been raised by anointing the chinks of doors, and the like;*

* I suppose this is meant of anointing them with the matter of the plague-sores, or other corrupt and excrementitious parts of a body infected.

not so much from the touch, as because it is common for men, when they find any thing wet upon their fingers, to put them to their nose: which one should therefore beware of. The best of it is, that these compositions for infecting the air, cannot be made without danger of death to the makers: but then, they may have antidotes to preserve themselves; so that men ought not to be too secure.

The French report, that at the siege of Naples, there were certain wicked merchants, who barrelled up man's flesh, and sold it for tunny; which proved the cause of the venereal disease.* And it is certain, that the cannibals in the West Indies, eat man's flesh; and the West Indies, when first discovered, were over-run with this distemper: and the most mortal poisons, practised by them, have some mixture of the blood, or fat, or flesh of man.

Great plagues have arisen, in several countries, from the putrefaction of great swarms of dead grasshoppers and locusts, thrown in heaps,

* The true cause of this distemper seems still uncertain; after all the enquiry that has been made after it. The principal reason of the uncertainty seems to be, that every enquirer carries his own idol, or some pre-conceived notion, along with him; to which he wrests all the facts and phenomena.

And damps frequently happen in mines; which kill either by suffocation, or the poisonous nature of the mineral: and those who deal in refining, or other works about metals and minerals, have their brain hurt and stupefied, by the metallic vapours. And it is observable, that quicksilver flies to the skull, teeth, or bones; insomuch, that gilders usually hold a piece of gold in their mouths, to attract the quicksilver: and this gold they afterwards find to be whitened. There are also certain lakes and pits, as that of Avernus, which poison the birds that fly over them; or men that stay too long near them.

The vapour of charcoal, or seacoal, in a close room, has killed many: and is the more dangerous, because unattended with any ill smell, but steals on by degrees; inducing only a faintness. When the Dutchmen wintered in Nova Zembla, and could gather no more sticks, they made a fire of some sea-coal they had; wherewith at first they were much refreshed: but soon after, there grew a general silence, and indisposition to speak, among them; when immediately one of the company fainted; whereupon suspecting what it was, they opened their door to let in the air: and thus saved themselves. The effect wrought by the inspissation of the air; of the breath and spirits. The like hap-

pens in rooms, newly plaistered, if a fire be made in them; by which means the emperor Jovinianus lost his life.*

POSTURES.

LYING, not upright, but hollow, from the make of the bed; or with the legs gathered up, from the posture of the body, is the more wholesome; because thus the stomach is better assisted; as being less pensile: and we see, that in weak stomachs, it is useful to lay the legs high, and the knees almost to the mouth. So galley-slaves, notwithstanding their misery otherwise, are commonly fat and fleshy; because the stomach is somewhat supported in sitting: but is pensile in standing or going. Therefore to prolong life, it is proper to chuse those exercises wherein the limbs move more than the stomach and belly; as in rowing,† &c.

Megrims and giddiness happen rather upon rising after long sitting, than while one sits; be-

* This death is said to have befallen many others, upon entering rooms that were kept close whilst the fire was burning to air them. For air becomes poisonous by passing through fire; as is now commonly known, from the air-pump; though the cause is not satisfactorily discovered.

† See the author's History of Life and Death.

cause the vapours, which were gathered by sitting, fly more into the head, upon sudden motion.

Leaning long upon any part makes it numb, and, as we call it, asleep: because the compression of the part, suffers not the spirits to have access; and therefore, as the part comes out of this numbness, we feel a pricking, which may be caused by the re-entrance of the spirits.*

PRESERVATION.

Tie a stock-gilly-flower gently upon a stick, and put it into a glass of quicksilver; so that the flower may be covered: then lay a little weight upon the top of the glass, to keep the stick down; and after four or five days, you shall find the flower fresh, and the stalk harder, or less flexible, than it was. By comparing this with another flower, gathered at the same time, the fact will be more manifest. Whence it appears, that bodies may be excellently preserved in quicksilver; and not only preserved, but also indurated by the coldness of the quicksilver: for though the freshness of the flower may be merely owing to conservation; yet the stiffness of the stalk, is owing to induration, from the

* This subject may deserve an accurate enquiry.

coldness, as it should seem, of the quicksilver.*

Earthen bottles filled with different liquors, and well stopped, were hung in a well of twenty fathom deep: and some bottles were let down into the water; whilst others were suspended within about a fathom of its surface. The liquors were beer, wine, and milk. The beer and the wine, as well within the water as above it, were not palled or deadened at all; but somewhat better than bottles of the same liquor kept in a cellar; though such as hung above the water were apparently the best: and the beer thus treated flowered a little; whereas that under water did not; though it was fresh. The milk soured, and began to putrefy. Yet there is a village near Blois, where, in deep caves, they thicken milk; so that it becomes very pleasant; which was one reason of our trial, though it did not succeed. Perhaps the milk, exposed in those caves, is first boiled: it were proper therefore to try it with boiled milk, and with cream: for milk is such a compound body of cream, curds and whey, that it usually turns and dissolves.†

* This experiment should by all means be repeated, varied, and extended to other bodies. See the article *Annihilation*.

† We noted above, under the article *Milk*, that the History of the Dairy was greatly wanting; and shall here add,

Pluck damask-roses, and dry them upon a lead, or terrace, in the hot sun; between the hours of twelve and two. Then put them into a sweet, dry glass, with a narrow mouth; pressing them close together; but without bruising: stop the glass tight; and the roses will thus retain, not only their smell in perfection, but likewise their colour fresh; for a year at least. Note, that nothing destroys any plant, or other body so much, whether by putrefaction, or arefaction, as the adventitious moisture, that hangs loose in the body; unless drawn out: for this moisture carries away the radical moisture, when itself goes off.* Whence also in living creatures, moderate sweat preserves the juices of the body.† Note, that the roses, when fully dried, as abovementioned, have little or no smell; so that their

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that the author has given several excellent hints relating to it; more, perhaps, than any one would expect, who has so attentively considered the subject, as to see that it enters deep into chemistry, and natural philosophy.

* This is an observation of great importance in natural philosophy; and particularly useful to chemists, apothecaries, druggists, perfumers, &c. whence it might deserve to be explained, illustrated, and verified, by a large induction.

† This also deserves to be explained along with the rest; and, indeed, the former observation is so general, as to reach the bodies of all the three kingdoms.

odour here is a secondary odour, that issues from the flowers afterwards.

'Tis strange, and deserves a careful observation, how long carcasses may continue uncorrupted, and in their own dimensions; as in the mummies of Egypt: which have some of them lasted, as is conceived, three thousand years. 'Tis true, they take out the brains and entrails, which are the parts aptest to corrupt: but the flesh itself is a soft corruptable substance. It should seem, that putrefaction, which we conceive to be so natural a period of bodies, is but an accident; and that matter hastens not so fast to corruption as is supposed. Whence bodies included in amber, quicksilver, balsams, wax, honey, gums, and perhaps in conservatories of snow, &c. are very long preserved.

If we provide against the three following causes of putrefaction, bodies will not corrupt *: the first is, that the air be excluded; for air undermines the body, and conspires with its spirit to dissolve it. The second is, that the adjacent body be heterogeneous to that designed to be preserved; for if nothing can be received by the

* It cannot well be too often inculcated, that to know the cause of things, is obtaining directions for stopping or over-ruling them; as also for employing them as agents in producing effects. See the Novum Organum, part II. sect. I.

one, nothing can issue from the other: such bodies are quicksilver, and amber, with regard to herbs, flies, &c. The third is, that the body to be preserved, be not so gross as to corrupt within itself, though no part of it issue into the adjacent body; and therefore it must be rather thin and small, than bulky.*

There is also a fourth remedy, if the body to be preserved is a thing of bulk, as a corpse, &c. for then, the inclosing body must have a virtue to draw forth, and dry up, the moisture of the inward one; else the putrefaction will play within, though nothing issue out. Livy relates, that there were found at the same time, two lead-coffins in a tomb; one that contained the body of king Numa; and the other, his books of sacred rites, ceremonies, and the discipline of the pontifs; and that in the first coffin, where the body had lain four hundred years, there was nothing to be seen but a little cinders about the sides; whilst, in the other, the books were found as fresh as if they had been newly writ-

* This enquiry is one of the most capital in all physics; putrefaction being the medium of the grand changes in material things; and the master-key of the principal operations, both of nature and art. On which account it should be earnestly recommended to all those who are concerned for the improvement of natural knowledge, and the production of capital works.

ten ; being of parchment, and covered over with wax-candles three or four doubles. By this it should seem, that the Romans in Numa's time, were not so good embalmers as the Egyptians; because the body was utterly consumed. But Plutarch, and others, relate that when Augustus Cæsar visited the sepulchre of Alexander the Great, in Alexandria ; he found the corpse to keep its dimensions : and though the embalming was, doubtless, the best for that time ; yet the body was so tender, that Cæsar touching but the nose thereof, defaced it. Which makes it appear strange, that the Egyptian mummies should be reported as hard as stone-pitch : but, probably, the ancient Egyptian mummies were shrouded in many folds of linen, besmeared with gums, in the manner of searcloth ; which, it does not appear was practised upon the body of Alexander.* See the article *Putrefaction*, and the *Preservation of Fruits*, under the article *Vegetables*.

* The art of embalming, whatever it may have been anciently among the Egyptians, is far from the degree of perfection in Europe, which, in all probability, it might arrive at. But as its perfection principally depends upon a just philosophical chemistry, it may require some ages yet, to advance it to its height : for philosophical chemistry has but of late began to appear in Europe. It may be worth enquiring, whether such improvements should not be

PRINCIPLES OF CHEMISTRY.

THERE are two great families of things, called by the chemists, sulphureous and mercurial, whereof their third principle, salt, is but a composition.* We may otherwise call these families of things inflammable and uninflammable, or mature and crude, or oily and watery. Thus, brimstone and quicksilver abound in the subterraneous regions, as the fathers of their tribes; oil and water, in the vegetable and animal kingdoms; air and flame, in the lower pneumatical regions; and pure æther and light, in the celestial spaces. And these pairs of things, though unlike in the primitive differences of matter, yet seem to have many agreements. Mercury and sulphur are the principal materials of metals: Water and oil are the principal materials of vegetables and animals; and seem to differ but in maturation or concoction. In short, these two tribes of things seem vastly extensive; so as to enter and occupy the whole material world. 'Tis therefore one of the greatest Magnalia Naturæ,

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made in the vulgar art of tanning, as might render it capable of preserving dead bodies in great perfection.

* See Mr. Homberg's Essays upon the Chemical Principles, in the French Memoirs, passim.

to turn water into oil; greater, in nature, than to turn silver or quicksilver into gold.*

There are four kinds of instances, wherein crude and watery substances turn into such as are fat and oily; viz. First, in the mixture of earth and water; which, by the help of the sun, acquire a nitrous fatness, more than either of them has severally; for thus they put forth plants, which require both oily and aqueous juices.† The second is the assimilation of nourishment, in the bodies of plants and animals; for plants turn the juices of mere earth and water, into so much oily matter.‡ Animals, though great part of their fat and flesh proceed from oily aliment, yet assimilate also, in some measure, the water they drink. But these two ways of converting water into oil, by mixture and assimilation, require many percolations, a long continuance of a soft heat, and several cir-

* This is to be understood not of any separation, but of an actual transmutation; so that the matter which had the full form and properties of water before, has now the full form and properties of oil. See the articles *Alteration* and *Transmutation*.

† See Mr. Boyle's Sceptical Chemist; and Dr. Woodward's Experiments upon the Growth of Vegetables, in the Philosophical Transactions.

‡ But, it may be suspected, that the unctuous matter is formed in the plant: Experiment must determine this.

culations. The third is the beginning of putrefaction; as in water corrupted, and the mothers of distilled waters; both which have a kind of fatness, or oil*. The fourth is, the edulcoration of some metals, or rendering of them saccharine; as in saccharum saturni,† &c.

The conversion of water into a more oily substance, is promoted by digestion; for oil is little more than water digested: and this digestion is principally carried on by heat; which heat must be either outward or inward. Again, this digestion may be forwarded by provocation, or excitation; which is caused by the admixture of bodies already oily or digested: for these will somewhat communicate their nature to the others. Digestion also is strongly performed by the direct assimilation of crude bodies, into bodies digested; as in plants and animals, whose nourishment is far more crude than their bodies: but this digestion requires, as was before observed, a length of time, and many circulations.‡

* Here lies a considerable secret. See Boerhaave's Chemistry; on the method of converting vegetable into animal matters, by means of putrefaction. Process 77.

† Here is another considerable secret; for saccharum saturni yields an inflammable spirit by distillation.

‡ The author intended a severe enquiry into the three chemical properties, salts, sulphur, and mercury. He has left us the introduction designed for it; which contains

See the articles *Alterations* and *Transmutation.*

PUTREFACTION.

THE introducing and accelerating of putrefaction, is an extensive subject; for corruption is reciprocal to generation: and these two are as nature's limits, or boundaries; and the conductors to life and death.*

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little more than what is delivered under the present article. Himself calls it one of the profoundest enquiries of nature; and brings under it, the heads of Conversion or the Transmutations of bodies, and the primary collections, or original congregations of matter; which, like a general assembly of a state, gives laws to all bodies. And though he makes the principal salt no more than a combination of sulphur and mercury, held together by a sharp spirit; yet he thought proper to admit it in his enquiry: not only on account of its relation to sulphur and mercury; but because of its extreme utility, as being the common link of the sulphureous and mercurial nature, and the rudiment of life itself. In this enquiry, had he prosecuted it, he proposed to have continued the use of the expressions, though he generally rejected the opinions of the chemists, as unsound. We may reasonably expect it would have been a grand and serviceable enquiry: but he left it for posterity to finish. Mr. Boyle, Sign. Guglielmini, M. Homberg, and Dr. Stahl, have all contributed to it.

* We have here the beginning of a regular enquiry into putrefaction; with a steady eye upon the processes of nature.

All putrefactions proceed, chiefly, from the internal spirits of the body; and partly from the ambient, be it air, liquor, or any thing else. The latter cause takes place by two means; viz. either by the entrance of the substance of the surrounding body into the putrefied body; or else by the excitation and solicitation of the putrefied body, and the parts thereof, by the surrounding body. As for the received opinion, that putrefaction proceeds either from cold, or preternatural heat, 'tis trifling: for cold, in things inanimate, is the greatest enemy to putrefaction; though it extinguishes vivification, which always consists in attenuated spirits, that congeal and coagulate with cold. But as for preternatural heat, 'tis so far true, that if the proportion of adventitious heat greatly predominate over the natural heat, and the spirits of the body; it tends to dissolution, or a considerable alteration: but this is wrought by emission, or suppression, or suffocation of the native spirits; and also, by the discomposure of the tangible parts, and other passages of nature; and not by a conflict of heats.

Putrefaction, therefore, is the work of the spirits of bodies; which are ever attempting to get forth, and congregate with the air, and enjoy the sun-beams. The escape, and spreading of the spirits, which is a degree of escape, appears in

five different operations: 1. If the spirits are detained within the body, and move violently, there follows colliquation, or melting; as in metals, &c. 2. If they move mildly, there ensues digestion, or maturation, as in drinks and fruits. 3. If the spirits be not merely detained, but protude a little, and the motion be confused and inordinate, then follows putrefaction, which always dissolves the consistence of the body with great inequality, as we see in putrefied flesh, rotten fruits, shining wood, &c. and also, in the rust of metals. 4. But if that motion be in a certain order, there follow vivification, and figuration, as in living creatures bred from putrefaction, and in perfect animals. 5. But if the spirits issue out of the body, then follow desiccation, induration, consumption, evaporation, &c.

The means of inducing and accelerating putrefaction are: 1. By the addition of crude or watery moisture; as in the wetting of flesh, fruit, wood, with water, &c. for, otherwise, unctuous and oily substances preserve themselves. 2. By invitation, or excitation; as when a rotten apple lies close to another that is sound: or when dung, a substance already putrefied, is added to other bodies. This also appears remarkably in church-yards, where the earth consumes a corpse in much shorter time than other earth will. 3

By closeness and suppression, which detains the spirits in prison, and thereby irritates them to seek issue, as in corn, and clothes, which grow musty; but are preserved fresh by the open air: and this appears more evidently in agues, which generally proceed from obstructions, and the penning up of the humours, which thereupon putrefy.* 4. By solution of continuity: thus, an apple will rot the sooner for being cut or pierced; so will wood; and the flesh of animals, where they have received any wound. 5. By exhaling or driving back the principal spirits, which preserve the consistence of the body; so that when their government is dissolved, every part returns to its nature. This appears in Urine and blood, when they cool; and thereby break: as also in gangrenes, or mortifications of the flesh, either by opiates or intense cold. I conceive, also, the same effect in pestilences, when the malignity of the infecting vapour disturbs the

* Were it not proper to range and class putrefactions into different kinds, that the enquiry might proceed with greater clearness and exactness? Vegetable, animal, and mineral putrefactions are very comprehensive heads, that allow of numerous subdivisions in this enquiry. Thus there is one putrefaction of wines, another of vinegars; one of milk, another of blood; one of vitriol, another of nitre, &c. that may be accounted so many species of putrefaction.

principal spirits, and makes them fly, and leave their government, whence the humours, flesh, and secondary spirits, dissolve and break, as in anarchy.* 6. By the entering of a foreign spirit, stronger, and more eager than the spirit of the body, as in the bite of the viper: And this is, generally, the cause that swelling ensues upon all poisons: which follows, also, when the spirits of the body congregate too much; as upon blows, and bruises; or when they are pent in too much, as upon swellings in cold. And the spirits proceeding from the putrefaction of humours in agues, &c. though bred within the body, yet extinguish and suffocate the natural spirits and heat. 7. By such a weak degree of heat as sets the spirits in a small degree of motion, but is not able either to discharge them, or digest the parts; as in flesh kept in a warm room; which, in a cool larder, would keep longer: and we see that vivification is affected by such soft heats as these; for example, in the hatching of eggs, the heat of the womb, &c. 8. By releasing the spirits, which before were close con-

* These expressions, though metaphorical, seem aptly, strongly, and scientifically, to express the nature of the thing. And till a philosophical language be introduced, perhaps, it is impossible to describe the internal natures of things, without some degree of metaphor.

fined by the solidity of their cover, whereby their appetite of issuing was checked ; as in artificial rusts, induced by menstruums, upon iron, lead, &c. and hence wetting hastens rust or putrefaction, because it softens the crust for the spirit to come forth. 9. By the interchanges of heat and cold, or wet and dry : as we see in the mouldering of earth exposed to frosts and the sun ; and in the more hasty rotting of wood, that is sometimes wet, and sometimes dry. 10. By time, and the operation, or process of the spirits ; which cannot keep their station, especially if left to themselves ; and there be no agitation or local motion ; as we see in corn not stirred; and men's bodies that are not exercised. All mouldiness is the beginning of putrefaction, as the mouldiness of meats, oranges, lemmons, &c. which mouldiness, afterwards, breeds worms, or more odious putrefactions; and therefore commonly proves of an ill odour. Or if the body be liquid, and not apt to putrefy totally, it will cast up a mother on the top, like the mother of distilled waters.*

* This subject of putrefaction, though so important in itself, seems to have been greatly neglected by philosophers. Some few hints are given us of it by Mr. Boyle, and sir Isaac Newton ; but Dr. Stahl appears to have

'Tis of great use to enquire into the means of preventing putrefaction; as therein consist the means of preserving bodies: for bodies have two kinds of dissolution; the one by consumption and desiccation; the other, by putrefaction.*

The first means of prohibiting putrefaction, is cold: for we see, that meat and drink will last longer unputrefied in winter, than in summer; and flowers and fruits, put in conservatories of snow, keep fresh. This cause operates by detention of the spirits, and constipation of the tangible parts.

The second means, is abstriction: for abstriction prevents dissolution; as we generally see in medicines; whereof such as are astringent, resist putrefaction: and, for the same reason, a small quantity of oil of vitriol will long preserve fresh water from putrefying.† And this astriction is found in a substance that has a virtual cold;

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carefully observed this grand process of nature, so as to continue the strict enquiry here begun by the author.

* These larger observations, as the author usually calls them, ought to be well attended to, by all who desire to continue his enquiries.

† This is proposed by a late author as a new discovery; and recommended as an effectual way of preserving fresh water at sea.

and works, partly, by the same means as cold.

The third is, exclusion of the air; and again, exposing to the air: for these contraries work the same effect, according to the nature of the subject-matter. So we see that beer, or wine, in bottles, close stopped, lasts long: that the garners under ground, keep corn longer than those above;* that fruit closed in wax, keeps fresh; as likewise bodies put into honey, or flour; and liquors, drinks, and juices, with a little oil on the top: as, on the contrary, cloth and apparel, not aired, breed moths and mould. The cause of the difference is, that in bodies requiring detention of spirits, the exclusion of the air doth good; as in drinks and corn: but in bodies that require emission of the spirits, to discharge some of the superfluous moisture, it doth hurt: for these require airing.

The fourth means, is motion and stirring; for putrefaction requires rest; its subtile motion being disturbed by any agitation; and all local motion keeps bodies entire, and their parts together. Thus, the turning of corn in a garner, or letting it run like an hour-glass, from an upper

* Insomuch that corn is said, by a proper exclusion of air and moisture, to have been preserved, under ground, for forty, fifty, or even a hundred years.

room into a lower, keeps it sweet: running waters do not putrefy; and in the body, exercise hinders putrefaction; as, on the contrary, rest, and want of motion, promote it.

The fifth means is the breathing forth of adventitious moisture, in bodies: for, as wetting hastens putrefaction; convenient drying, whereby only the more radical moisture is kept in, prevents it: so we see, that herbs and flowers, if dried in the shade, or in the hot sun, for a short time, keep better: for, without this drying, the emission of the loose and adventitious moisture, betrays the radical moisture, and carries that out with itself.

The sixth means is strengthening the spirits of bodies; for as a great heat keeps bodies from putrefaction, but a tepid heat inclines them to it; so a strong spirit preserves from, and a weak or faint spirit disposes to corruption. Thus, salt water corrupts not so soon as fresh; and salting of oysters, and meat, keeps them from putrefaction. It should be also tried, whether chalk does not preserve water from putrefying, or drink from speedy souring;* strong beer will

* Chalk seems to preserve water, in some degree; but makes wine run sooner into corruption. Those who will try the experiment, may here find a considerable secret, with relation to vinous and acetous fermentation, and putrefaction.

last longer than small: and all things that are hot and aromatic, help to preserve liquors*, or powders, &c. which they do as well by strengthening the spirits, as by soaking out the loose moisture.

The seventh means is a separation of the cruder parts, which renders the body more equal: for all imperfect mixtures are apt to putrefy; and watery substances are more apt to putrefy than oily.† So distilled waters will last longer than raw waters; and things that have passed the fire, longer than those that have not passed the fire; as dried pears, &c.

The eighth means is drawing forth, continually, that part where the putrefaction begins; which is, commonly, the loose and watery moisture: not only because it provokes the radical moisture‡ to come forth with it; but also be-

* Here, again, is a considerable secret intimated. Thus, for instance, how strongly soever the vulgar notion may run that brandy is an enemy to wine, as they phrase it; yet the cooper upon the spot, knows that most wines, and even ports, require to be dosed with brandy, to fit them for the market.

† Here, again, are two larger observations, almost fitted for axioms.

‡ If any objection be made to the word, essential moisture may be used in its stead; as in raisins, for instance, their radical, or essential moisture, is only the saccharine

cause, being detained in the body, the putrefaction takes hold of it, and thus infects the rest, as we see in the embalming of dead bodies: and the same holds of preserving herbs, fruits, or flowers, in bran or meal.

The ninth means is the commixture of things more oily or sweet; such being least apt to putrefy, for the air works little upon them: whence such bodies, not putrefying themselves, they preserve the rest: thus we see syrups, and ointments, last longer than juices.

The tenth means is the commixture of somewhat dry; for putrefaction begins first from the spirits, and then from the moisture; but dry things are unapt to putrefy: whence smoke preserves flesh: as we see in bacon, neats' tongues, &c. The opinion, that condensed air preserves bodies longer than other air, seems probable; because condensed air being overcharged and compressed, will hardly receive, but rather repel the exalations of any thing. It was tried in a blown bladder with flesh, and a flower; but without success: for dry bladders will not blow; and new bladders rather promote putrefaction. The way, therefore, is to blow strongly with a pair of bellows, into a

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juice, and not the aqueous part, wherewith it is mixed in the grape.

vessel containing what you would have preserved; and stopping the orifice at the instant the bellows are withdrawn.*

RAIN.

'Tis strange, that though the river Nile overflows Egypt, there should be little or no rain in that country. The cause is either in the nature of the water, the nature of the air, or both. It may be ascribed to the long course of the water; for swift-running waters evaporate not so much as standing waters: or to the concoction of the water; for waters well concocted, evaporate not so much as crude waters: and water upon the fire, evaporates not so fast after some time boiling, as at first. But the water of the Nile is sweeter than other water in taste; and excellent for the stone, and hypochondriac melancholy; which shews it to be lenifying. It also runs through a hot and flat country, without shade either of hills or woods: whence the sun must needs have great power to concoct it. As for the air, it may be thin and thirsty; so as

* This latter part of the enquiry has been largely prosecuted by Mr. Boyle. See his Pneumatical Experiments, passim. But in what we may call the more internal, physical, or chemical part, it seems to have been almost overlooked by the generality of philosophers, considering the discoveries it might afford.

when it receives any moisture from the water, to imbibe and dissipate it through its whole body, and not suffer it to remain in vapour, so as to be the cause of rain.* See the article *Air*.

RAINBOW.

It is observed by the ancients, that where a rainbow seems to hang, or touch the earth, there breathes a sweet odour. If the fact be true, the cause may be, that this happens in certain matters, having in themselves some sweetness, which the fine dew of the rainbow draws out: for thus soft showers make the ground sweet. Perhaps, also, the water itself of the rainbow, has some sweetness; for the rainbow consists of a collection of small drops, which cannot possibly fall but from the air that is very low; and therefore may lodge the sweetness of the herbs and flowers, as a distilled water: for rain, and other dew that falls from on high, cannot preserve the smell; which is dissipated in the drawing up. Some waters also, may have a degree of fragrance; though we find it sensibly in no pool, river, or fountain: but clean earth, newly turn-

* But small advances have been yet made towards an inductive meteorological history: whence most points relating to it, are little better than conjectural; except what the author has in his History of Winds.

ed up, hath a freshness and good scent; which water, if it be not too equal and uniform (for equal objects never move the senses) may also have. Bay-salt, which is but a kind of congealed water, will sometimes smell like violets.*

RAREFACTION.

Barley swells but little in boiling; wheat more; and rice extremely, even to three times its bulk. The cause is, that the more close and compact bodies will dilate the most: but barley is hollow, wheat more solid, and rice the most solid of all. Perhaps, also, some bodies have a kind of lentor, and a more communicable nature than others; as we see in coloration: for a small quantity of saffron will tinge more than a great one of brasil.†

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* Consult, upon this head, the Chapter of Water, in Boerhaave's Chemistry; and the Processes upon Vegetables, in the same work.

† Here is an useful subject started, that might deserve to be largely prosecuted, in a History of dry or solid Panadas, Gruels, Jellies, Mucilages; and various other sorts of cheap, parable, and wholesome aliments, both for the sick and sound, as well at sea as at land. But the thoughts of such a history seem nauseated by philosophers; and, till this nausea be removed, the subject must skulk in the kitchen.

REJUVENESCENCY.

THE casting of the skin is, by the ancients compared to the breaking of the secundine; but unjustly: for thus every casting of the skin were a new birth: besides, the secundine is a general cover, not shaped to the parts, as the skin is. The creatures that cast the skin are, the snake, the viper, the grasshopper, the lizard, the silk-worm, &c. Those that cast the shell are, the lobster, the crab, the craw-fish, the dodman, the tortoise, &c. The old skins are found; but the old shells never:* so that, perhaps, they scale off, and crumble away by degrees. This renovation is known by the extreme tenderness and softness of the new shell, joined with the freshness of its colour. The cause of casting the skin and shell, should seem to be, 1. the great quantity of matter in those creatures, fit to produce them; and, 2. the looseness of the skin, or shell; that sticks not close to the flesh: for it is the new skin, or shell, that thrusts off the old. In deer, it is the young horn that pushes off the old one; in birds, the young feathers displace the old: And birds that have

* Consult the French Memoirs; and Philosophical Transactions, upon this point.

much matter for the beak, cast their beaks; the new ones thrusting off the old.*

RIGHT AND LEFT.

THE senses are alike strong, both on the right and left side; but the limbs on the right side, are strongest.† The cause may be, that the brain, which is the instrument of the sense, is alike on both sides; whilst the motion and hability of moving are somewhat forwarded by the liver; which lies on the right-side. Perhaps, also, the senses are exercised indifferently on both sides, from the time of birth; but the limbs are used most on the right-side, by custom: for we see some are left-handed; who are such as have used the left-hand most.‡

* These are to be understood as instances of approach, in the subject of rejuvenescency; that ought to encourage an enquiry into the means of renewing the body in old age. But men seem to shew all the frigidity, and despondency of age, on this occasion.

† Except in left-handed people.

‡ May there not be a particular and original conformation in the limbs of some persons, disposing them to use their left-hand, or left-leg, more than their right? for considerable pains have been taken, to break some children of the habit of using the left-hand; but without success. It might likewise deserve to be examined, whether the right-side limbs of the body do not naturally grow larger than

SALAMANDER.

THERE is an ancient tradition of the salamander, that it lives in, and has the power of extinguishing fire. If this be true, two things are required to the operation: first, a very close skin, to keep out flame; which, in the midst, is not so hot: for, if the palm of the hand be besmeared thick with the white of an egg, and spirit of wine be poured upon it, and set on fire, one may endure the flame for some time. The second thing is, an extreme coldness, and quenching virtue, in the body of that creature; which chokes the fire. We see that milk quenches wild-fire better than water; because it enters better.*

SALT WATER.

IT has been observed, that salt water boiled, and cooled again, is more potable than when raw; yet the taste of the salt does not rise in vapour: for the distilled water proves fresh. The cause may be, that the salt of the water partly

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the left, in most people; without their using them more: This should be tried in ambodexters, &c. The right testicle seems, generally, bigger than the left.

* These intimations of the author receive great confirmation from the observations of M. Maupertuis, made upon the land salamander; and published in the French Memoirs of the year 1727.

rises in a kind of scum, and partly falls in sediment; and so, rather separates than evaporates: a saline taste being too gross to rise in vapour, as well as a bitter one; for the simple distilled waters of wormwood, and the like bitter plants, are not bitter.* See the article *Percolation*.

SEA.

THE sea is clearer when the north, than when the south-wind blows: for salt water has a little oiliness on its surface; as appears in very hot days. And again, a south-wind somewhat warms

* The due prosecution of this enquiry requires a distinction to be observed betwixt salt-water and sea-water; otherwise many fruitless experiments may be made for separating common salt, dissolved in common water, that shall by no means come up to the case of rendering sea-water sweet and potable. An exact analysis of sea-water seems hitherto wanting; to shew its several ingredients, and their proportions. Thus it may, upon examination, be found to contain a bitter unctuous or bituminous matter, and the putrefied substance of fish, &c. as well as a certain proportion of common salt; and it must be purified from all these, before it can serve the purposes of common water. What effect will the filtering-stone have, in separating the foul, unctuous, putrefied, and saline parts of sea-water? Who has shewn the methods that seem best adapted for obtaining of this end; whether precipitation, separation, percolation, inversion, distillation, or congelation? There are some hints to this purpose in the writings of Mr. Boyle; the Phi-ophical Transactions; and the French Memoirs.

or relaxes the water; and no water when boiling, is so clear as when cold.*

Shallow, narrow seas break more than deep and large ones: for the impulse being the same in both; where there is a greater quantity of water, and space enough, the water rolls and moves more slowly, and with a sloper rise and fall: but where there is less water, less space, and the water dashes more against the bottom, it moves swifter, and more perpendicularly; for in the breaking of waves, there is always a precipice.†

SENSES.

HARSH sounds, as that of a saw when it is filing, make a shivering or horror in the body,

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* There may be somewhat optical in this case, besides the causes here assigned: thus, for instance; a river, or the sea, will sometimes appear clear and undisturbed on one hand, and muddy, or ruffled on the other; according to the situation of the eye: or as some light breeze catches the surface of the water, and ruffles it in a particular part. But for the clearness of the sea, at great depths, see Dr. Halley's Account of the Diving-Bell, in the Philosophical Transactions.

† See more to this purpose in the author's Account of the Ebbing and Flowing of the Sea; in the Philosophia Prima.

and set the teeth on edge; for the objects of the ear affect the spirits immediately, either with pleasure or offence: but no colour affects the eye with great displeasure. There are, indeed, sights that are horrible; because they excite the memory of things odious: whilst the same things painted, have little effect. But for smells, tastes, and touches, they affect by a participation, or impulse of the body of the object. It is sound alone, that affects most immediately and incorporeally. This is manifest in music, with its concords and discords; for all sounds, whether sharp or flat, if they be sweet, have a roundness and equality; and if harsh, are unequal: for a discord itself, is but a harshness of differing concurrent sounds. It is true, inequality not dwelt upon, but transient, is rather an increase of sweetness; as in the purling of a wreathed string; the hoarseness of a trumpet; and the nightingale-pipe of a regal; and in a discord falling directly upon a concord: but dwelt upon, it is offensive. Hence there are three degrees of pleasure and displeasure, in sounds; viz. sweet sounds, discords, and harsh sounds, which are differently named, shrieking, grating, &c. As for setting the teeth on edge; we may plainly observe, what an intercourse there is between the teeth and the organ of hearing, by taking the

end of a bow in the teeth, and striking upon the string.*

SEPARATION OF BODIES BY GRAVITY.

PUT water into the belly of a glass-egg, and a parcel of claret and water, mixed, into another open glass; invert the stem of the egg into the wine and water, stopping the orifice with the finger; then removing the finger, continue the glass in the same posture; and it will unmix the wine from the water: the wine ascending to the top of the upper glass, and the water descending to the bottom of the lower.† The operation is apparent to the eye; for the wine will visibly rise, in a small vein, through the water. To render the experiment more elegant, and because it requires some small time, the upper glass may be suspended: but as soon as there is so much pure unmixed water collected in the bottom of the lower glass, that the mouth of the upper dips into it, the motion ceases.

If the upper glass be charged with wine, and the lower with water, there follows no motion at

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* See this subject farther prosecuted under the articles *Affections*, *Music*, *Odours*, and *Sound*.

† There is some caution required to make the experiment succeed; particularly, the stem of the glass-egg should be slender.

all: and if the upper glass be of pure water, and the lower of water coloured, there follows no motion. But it has been tried, that though the mixture of wine and water, in the lower glass, be three parts water to one of wine, it does not slacken the motion. This separation of wine and water appears to be made by gravity: for it only succeeds in bodies of unequal gravity; and the heavier body must always be in the upper glass: but then observe, that the water being pensile, and there being a great weight of water in the belly of the glass, sustained by a small pillar of water in the neck, is the thing that gives the motion; for water and wine in one glass, will hardly separate by long standing.*

This experiment should be extended to mixtures of different liquors, and to fluids which consist of several similar parts: try it therefore with brine, or salt water, and fresh water; placing the salt water in the upper glass, to see whether the fresh will rise. Try it, also, with water sugared, and pure; to see whether the water that rises will lose its sweetness: for which purposes, it were proper to have a little stop-cock in the belly of the upper glass.†

* This being tried with red Port wine and water; there was no manifest separation in a month's time.

† The experiments of this kind are attended with difficulties, and not yet brought to perfection. See the Essay

SHADOWS.

THE extremities of shadows always seem to tremble; because the little motes in the sun are constantly in motion; though there be no wind: and these moving in the meeting of the light and shade, from the light to the shade, and from the shade to the light, may make the shadow appear to move, because the medium moves. *

SHELL-FISH.

SHELL-FISH have been compared, and ranked with insects; but, I know not why: for they have male and female, like other fish; and are not bred of putrefaction. Indeed oysters, cockles, and muscles, which have no local motion, have no discriminate sex. Quere, in what time, and how they are bred? It seems, that shells of oysters grow where there were none before; and the great horse-muscle, with the fine shell, found in ponds, has bred within thirty years: but then, they not only open and shut, as oysters do, but also remove from place to place.†

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lately published for Concentrating Wines, and other fermented Liquors, or taking their superfluous Waters out of them to Advantage.

* See more to this purpose in Sir Isaac Newton's Opticks.

† Thus, at the bottom of dry ponds where muscles are,

It is common for more to be sick in summer, and more to die in the winter; except in pestilential diseases, which usually reign in the summer, or autumn. The reason seems to be, that diseases are chiefly caused by heat;* and chiefly cured by sweating and purging: which operations are more easily excited in summer. But most die of pestilential diseases in summer; because these breed most in that season: otherwise the constitutions that are touched, run the greatest danger in winter.

It is a general opinion, that hot and moist years are most pestilential; and, that heat and moisture cause putrefaction upon the surface of the earth. In England, this is not true; for there have often been great plagues in dry years: perhaps, because drought, in the bodies of the islanders, accustomed to a moist air, exasperates the humours, and makes them more apt to putrefy, or inflame: besides, it commonly taints the waters, and makes them less wholesome.

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it is usual to find several long traces; made by the motion of the muscle that lies at the end of each trace, respectively. There is a curious paper upon this subject of muscles, in the French Memoirs.

* This seems to hold of inflammatory diseases; which are, perhaps, by much, the greatest number.

Again, in Barbary, plagues break out in the summer months; when the weather is hot and dry.

Many diseases rage at particular times: the cause whereof is falsely imputed to the constitution of the air at that time; being, in reality, owing to a series of the seasons of the year: whence Hipocrates, in his Prognostics, justly observes the diseases that ensue upon the nature of the four precedent seasons of the year.*

SLEEP.

THERE are many creatures that sleep all the winter; as the bear, the hedge-hog, the bat, the bee, &c. and they all grow fat by sleeping; and void nothing. The cause of their fattening may be, the want of assimilation; for whatever does not assimilate to flesh, turns either to sweat, or fat. These creatures, for one part of their sleeping time, have not been observed to

* There is matter of instruction here laid down, in order to a Natural History of Diseases: a thing greatly wanted; if it could be procured without any mixture of hypothesis, fiction, and fancy, wherewith the writings of physicians generally abound. But no great progress can well be expected in it, without a previous enquiry into the natural chemistry of the weather, and its effects on the body, through the different seasons of the year. See the author's History of Winds.

stir; and, for the other part, to stir, but not to remove: and they chuse warm, close places, to sleep in. When the Dutch wintered in Nova Zembla, the bears went to sleep about the middle of November; and then the foxes, which durst not appear before, began to come abroad. It is observed, by some, that the she-bear breeds, and lies with her litter, during this time of rest: and, that a bear big with cub, has been seldom seen.

Those that are very cold, especially in their feet, cannot soon go to sleep. The cause may be, that sleep requires a free respiration, which cold hinders; for in great colds a man can scarce draw breath. Another cause may be, that cold calls out the spirits to assist against it: whence they cannot so well come together, and collect in the head; which is always required in sleep. And, for the same reason, pain and noise prevent sleep; which darkness promotes.

Some sounds incline to sleep; as the blowing of the wind, the trickling of water, the humming of bees, soft singing, reading, &c. The cause is, that they move in the spirits, only a soft and gentle attention; and whatever moves attention, without too much labour, stills the natural and discursive motions of the spirits.

Sleep nourishes, or, at least, preserves bodies a g time. Beasts that sleep the winter, grow

fat though they eat nothing. Bats have been found in ovens, and other hollow, close places, matted one upon another; whence, it is probable, they sleep in the winter, and eat nothing. Quere, whether bees do not sleep all the winter; and spare their honey? butter-flies, and other flies, not only sleep, but lie as dead, all winter; yet revive again, with a little heat of the sun, or a fire. A dormouse will sleep for some days together, both in winter and summer, without eating.*

SNEEZING.

LOOKING against the sun provokes sneezing;† not by heating the nostrils; but by drawing down the moisture of the brain: for it will make the eyes run with water; and the drawing of moisture to the eyes, draws it to the nostrils, by consent; whence follows sneezing: as, contrariwise, the tickling of the nostrils within-side, draws moisture to the nostrils, and to the eyes by consent; for they, also, will water. Yet it has been

* There are many particulars relating to this history of sleep, to be found in Mr. Boyle's Philosophical Works; the Philosophical Transactions, &c. But the subject requires to be farther continued, in the inductive method. See the author's History of Life and Death.

† This perhaps may have sometimes been tried without success.

observed, that if a person be going to sneeze, the rubbing of the eyes, till they water, will prevent it: the humour, which was descending to the nostrils, being thus diverted to the eyes.*

A DRAUGHT FOR THE PARTICULAR HISTORY OF PHONICS: OR THE DOCTRINE OF SOUND AND HEARING.

INTRODUCTION.

SOUND is a capital thing, and a great secret in nature; as having a virtue that may be called incorporeal: whereof there are but few other instances. And besides the more obvious uses of an enquiry into this subject, it affords a proper exercise to the understanding, by mixing the contemplation of spiritual species, and operations at

* The present anatomy, and physiology, scarce reach to these subtile operations of the body, nor can we hope to see their causes investigated, without proper sets of experiments, which few seem, hitherto, disposed to make, certainly, a more active and penetrating philosophy is here required, than the vulgar philosophers are apprized of; as consisting, not in the gross, but almost infinitely fine particles of matter, which too commonly pass for notional things; though the immediate instruments of all the more subtile operations. But, perhaps, the time for these things is not yet.

a distance; with the consideration of such things as operate only by a communication of substance to the touch. Whence the mind now called off from matter, may be rectified, and taught to become impartial.* But certain observations upon sounds, having given birth to the art of music; † it happens here, as it generally does, that when experiments and observations are grown into an art; the mathematical and practical parts of that art improve, whilst its physical part is deserted. It has fared somewhat better with optics; which considers not only painting, beauty and symmetry, but all visible objects; whereas music confines itself only to harmonic tones; which is a narrow field: but the business of sound and hearing should be well laboured in all its parts; and brought into a full and extensive history.‡

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* See this direction explained in the Novum Organum, Part I. Sect. II, 18, &c.

† See the article *Music*.

‡ The following is a large example of a history conducted according to the direction of the Novum Organum; and a specimen how all the articles of the Sylva Sylvarum would have been treated, had the author lived to execute his vast design. Indeed the present enquiry, though not finished, is prosecuted to such a length as might recommend it to a place in the fourth part of the instauration; if the author had not here intended it as a model of his method of prose-

A TABLE OF ENQUIRY, FOR THE PARTICULAR HISTORY OF PHONICS.

ARTICLE I. Of the existence and non-existence of sounds.

II. Of the production, conservation, and propagation of sounds.

III. Of the magnitude, smallness, and damps of sounds.

IV. Of the loudness, or softness of sounds, and their propagation to longer or shorter distances.

V. Of the communication of sounds.

VI. Of the equality and inequality of sounds.

VII. Of the more treble and more bass tones, or musical sounds.

VIII. Of the proportion of treble and bass tones.

IX. Of external and internal sounds.

X. Of the articulation of sounds.

XI. Of the duration of sounds; and the time they require in their generation or propagation.

XII. Of the direction of sounds.

XIII. Of the passage and interception of sounds.

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cuting enquiries; so as in the third part of his grand work, to give some earnest of the fourth: which is a rule he appears to observe in all the parts that are touched upon.

XIV. Of the medium of sounds.

XV. Of the figures of the concaves, or bodies through which sounds are conveyed.

XVI. Of the mixture of sounds.

XVII. Of the melioration of sounds.

XVIII. Of the imitation of sounds.

XIX. Of the reflection of sounds.

XX. Of the relation and difference betwixt light and sound.

XXI. Of the sympathy and antipathy of sounds with one another.

XXII. Of the means of hindering or improving the hearing.

XXIII. Of the spiritual and fine nature of sounds.*

* These are the several articles, or heads of enquiry, which occur upon the first sedate consideration of the subject; and which being duly enlarged, enquired into, and the necessary experiments, observations and instances produced, lead to a knowledge of its nature and properties; or what, in the language of the author, is termed its form. But till these articles are all filled up, the instances produced, and the whole extended, verified, and deduced into axioms, it is no more than a Sylva, or bare collection of the materials for a particular history of phonics.

SECT. I.

OF THE EXISTENCE AND NON-EXISTENCE OF SOUNDS.

LET us first consider what great motions there are in nature, that pass without sound, or noise. The heavens revolve in a rapid motion, without noise; though, by some dreamers, they have been said to make excellent music. The motions of the comets yield no noise. And if it be thought that the greatness of their distance will not let the sound be heard; we say that lightnings, and corruscations, which are near at hand, yield no sound: yet in all these, there is a percussion and separation of the medium.

The winds in the upper region, blow without noise. The lower winds, in an open plain, make no noise; unless they be violent: but among trees their noise is perceptible. And the sound of winds is generally unequal, or in the way of rising and falling; and sometimes, when vehement, trembling at the height of their blast.

Rain or hail, though falling violently, yield no noise in passing through the air, till they reach the ground, water, houses, or the like. The water of a river is not heard in the channel; but runs silent, if it be of any depth; whilst the smal-

ler streams upon shallows of gravel, or pebble, make an audible noise. And waters when they beat upon the shore, or are straitened, as in the falls of bridges, or when dashed against themselves, by winds, make a loud roaring.

Any piece of timber, or hard body, being thrust forwards by another contiguous to it, without knocking, gives no noise. And so bodies in weighing upon one another, though the upper press the lower, make no noise. Thus the motion in the minute parts of any solid, passes without sound; the sound being here produced only by the breaking of the air, and not by the impulse of the parts: so that where the anterior body gives way as fast as the posterior comes on, no noise is made; be the motion ever so great or swift.

Air open, and at large, makes no noise, unless it be sharply struck; as in the sound of a string; where the air is briskly struck by a hard and stiff body: for if the string be not strained, it makes no noise. But where the air is confined and straitened; the breath, or other blowing, with a gentle percussion, suffices to create sound; as in pipes, and wind-instruments. But in flutes, which require only a soft breath, the concavity of the instrument would yield no sound, were it not for the fipple that straitens the air. Other wind-instruments, as trumpets, cornets, horns, &c. require a forcible breath; as appears by the

inflated cheeks of the blower. Organs also are blown with a strong wind, by the means of bellows. And some kinds of wind-instruments are sounded at a small hole on the side,* which straitens the breath at the first entrance: and this the rather, on account of their traverse and stop above the hole; which performs the part of the fipple, in flutes and fifes, that give no sound when blown at the wrong end, as recorders do. So in whistling, it is usual to contract the mouth; and to make the tone more sharp, they sometimes use the finger. But if a stone, or a dart, be thrown in the open air, they give no sound: no more do bullets, unless they happen to be a little hollowed in the casting; which hollowness receives and confines the air.† Arrows, likewise, whiz not in their flight, except their feathers are ruffled; which likewise obstructs and confines the air. But small whistles give a sound, on account of their extreme slenderness; whereby the air is more confined than in a wider bore. Again, the voices of men, and other animals, pass through the throat; which confines the breath. The jews-harp requires but

* As the German flute, for instance.

† Suppose a brass bullet turned exactly smooth, and discharged in the common manner; will it make no sensible whizzing as it flies through the air?

a small percussion; and has also the advantage of confining the air in the mouth.

Solid bodies, if gently struck, give no sound; as when a person treads softly upon a floor. So chests or doors in dry weather, when they open easily, make no noise: and cart-wheels squeak not if they are greased. The flame of tapers, though it be a swift motion, and breaks the air, yet passes without sound. The air in ovens, though it doubtless boils, as it were, dilates itself, and is beat back; yet makes no noise. Flame repulsed by air, affords a noise; as in blowing the fire with bellows; greater than if the bellows were to blow upon the air itself. So likewise flame striking the air strongly, makes a sound: and great flames roar whilst one impels another.

There goes a rumour of a kind of white gunpowder, which will discharge a piece without noise; and it is a dangerous experiment if true.*

* White gunpowder has frequently been made by using touch-wood, which is white, instead of willow-coal, which being black, communicates a dusky hue to the common gunpowder. But this kind of white powder still makes a report; so does the common white pulvis sulminans: but what approaches the nearest of any thing yet discovered, to the design of the white powder here understood, is, perhaps, condensed air, in the wind-gun; which, when well made, is indeed a highly dangerous and destructive engine,

But it seems to me impossible; for if confined air be driven out, and strike the open air, it will certainly make a noise.* As for the white powder, it may be a mixture of nitre, sulphur, and a little camphire, without coal; for nitre alone will not take fire: nor is it probable, that the sound should be damped or deadened by discharging the condensed air, before it comes to the mouth of the piece, and the open air: for it will thus only make more divided sounds. If it were possible, there should be no air confined at the mouth of the piece, the bullet might go away with little noise: for the percussion of the flame upon the bullet makes no noise: the bullet in passing through the air, makes but little: and if no confined air were to strike upon the open air, there is no cause of sound; yet the bullet's motion will not be stopped. So that the trial may be made, by filling a little hollow metalline cylinder with powder; and laying the bullet in the mouth of it, so as to reach half out into the open air.

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capable of doing execution, where its slender and short-lived hissing report cannot be heard.

* So it does in the wind-gun; but nothing like the noise of gunpowder, even when the wind-gun is high charged with condensed air; so as to throw out twenty bullets successively; in the space of a minute.

I heard it affirmed by a great, though vain, dealer in secrets, that there was a conspiracy, which himself hindered, to have killed Queen Mary, sister to Queen Elizabeth, by a burning-glass, from the leads of the house, as she walked in St. James's Park. And if burning-glasses could be brought to a great degree of strength, (and they talk of glasses able to fire a navy) the percussion of the air alone, by such a burning-glass, would make no noise; any more than corruscations and lightnings, without thunder.

I suppose the impression of the air by sounds, requires time to reach the sense, as well as the impression of visible objects; and will not otherwise be heard. Therefore, as a bullet from a cannon, moves so swift, as to be invisible;* the same swiftness of motion makes it inaudible: for the apprehension of the eye, is quicker than that of the ear.

All eruptions of the air, though small and light, cause the sounds called crackling, puffing, spitting, &c. as in salt, bay-leaves, and chestnuts, thrown into the fire: so candles will spit flame, if they be wet, &c.

* Red-hot bullets discharged in the dark are visible; and so, perhaps, are brass bullets discharged by day; when the spectator stands with his back to the sun, whilst the sun's rays play directly upon the ball in its motion.

SECT. II.

THE PRODUCTION, CONSERVATION, AND PROPAGATION OF SOUNDS.

THE cause commonly assigned of sound, viz. the elision of the air,* is but a term of ignorance; and the notion but a catch of the wit upon a few instances; as the manner is, in the received philosophy. And it is a common way with men, when once they have got a pretty expression, or a term of art, by the end; to let it go current: though it be empty of matter. This conceit of elision appears manifestly false; because the sound of a bell, a musical string, or the like, continues melting for some time after the percussion; but ceases presently, if the bell, or string be touched and stayed: whereas if an elision of the air made the sound; the touch of the bell or string could not so suddenly extinguish the motion caused by an elision of the air. This appears still more plain by chiming, with a hammer, upon the out-side of a bell; for the

* That is in plain words, the squeezing, pressing, or cutting of the air; as betwixt the hammer and the anvil, the bell and its clapper, the finger and a musical string, &c.

sound will thus be made according to the inward concave of the bell: whereas the elision of the air can be only between the hammer and the outside of the bell. So again, if elision were the cause; a broad hammer, and a bodkin, struck upon metal; would give different tones, as well as a different loudness; which they do not: for though the sound of the one be louder, and of the other softer; yet the tone is the same.* Besides in echoes, whereof some are as loud as the original voice, there is no new elision; but only a repercussion. These and the like conceits, will scatter and break up like a mist; when men shall have cleared their understanding, by the light of experience.

It is certain, that sound is not produced at the first, without some local motion of the air, flame, or other medium; nor without some resistance, either in the medium or body struck. For a mere yielding, or cession, produces no sound.

* It is a difficulty with many to acquire a just notion of this matter; and the thing itself is seldom clearly made out, how a bell, or a musical string, struck in any part, or with any degree of force, should still give one and the same tone; differing only in loudness or lowness. The knowledge of this is rather to be acquired by the ear, and experience, than by words. But if farther direction be required, consult Mr. Malcolm's Treatise of Music. See also below, Sect. IV. and VIII.

And herein sounds differ from light and colours, which pass through the air, or other medium; without any local motion of the air, either at the first, or after. But we must attentively distinguish between the local motion of the air, and the sounds conveyed in the air. As to the former, we manifestly perceive, that no sound is produced without a perceptible blast of the air; or without some resistance of the air that is struck. For even speech, one of the gentlest motions of air, is attended with the expulsion of a little breath. And all pipes or wind-instruments have a blast, as well as a sound. We find also that sounds are carried by the wind, and therefore will be heard farther with the wind, than against it; and that they likewise rise and fall with the intension or remission of the wind.* But for the impression of sound, it is quite another thing; and entirely without any perceptible local motion of the air: in which it resembles vision ;† for after a bell is rung, we discern no perceptible motion of the air, in the track where the sound goes, but only at the first. Nor does the wind, in carrying a voice, by its motion, con-

* See Mr. Derham's Paper upon the Motion of Sound, in the Philosophical Transactions, No. 313.

† See the Bishop of Fern's Paper upon Acoustics, in the Philosophical Transactions, No. 156. And Dr. Grandi's Considerations upon it, No. 319.

found any of the delicate and articulate figurations of the air, in the variety of words. And to speak loud against the flame of a candle, will not make the flame tremble considerably; though most when those letters are pronounced which contract the mouth; as F, S, U, &c. But gentle breathing, or blowing, without speaking, will move the flame much more. And probably sound is the rather without any local motion of the air; because, as it differs from sight, in requiring a local motion at first; so it resembles it in many other things, which induce no local motion.*

On the other hand, glass windows will shake with thunder, and the firing of ordnance; and fishes are thought to be frighted with the motion, caused by noise upon the water: but these effects proceed from the local motion of the air, which is a concomitant of the sound; and not from the sound itself. It is also said, that violent shoutings of people in great multitudes, have so rarified the air, that birds upon the wing have fallen down; the air being thus rendered unable to support them.† And it is believ-

* See the Paper above cited.

† Allowing that birds have been made to fall down by loud shouting, it does not follow that the air must have been rarified by the noise: for the birds may only be thus frighted by the noise, so as to fall down.

ed by some, that violent ringing of bells in populous cities, has chased away thunder; and also dissipated pestilent air: all which if real, may proceed from the concussion of the air, and not from the sound. A very great sound, near at hand, has struck many with deafness: and at the instant they have found, as it were, the breaking of a skin or parchment in their ears:* and myself standing near a person who luted loud and shrill, suddenly received an injury; as if somewhat had broke, or been dislocated in my ear; and immediately after ensued the sensation of a loud ringing; so that I apprehended some deafness: but it vanished in half a quarter of an hour. This effect may be justly referred to the sound; for an over potent object destroys the senses: and spiritual species, both visible and audible, will affect the sensories, though they move no other body.

In the propagation of sounds, enclosure of them preserves, and carries them farther. Thus in rolls of parchment, or shooting trunks, the mouth being applied to one end of the roll or trunk, and the ear to the other; the sound is heard much farther than in the open air: for the

* Hence, perhaps, some countenance to the opinion, that drum of the ear was the instrument of hearing. But not well confirmed.

sound spends and dissipates in the open air; but is conserved and contracted in such concaves. So, if one man speak in the touch-hole of a piece of ordnance; and another apply his ear to the mouth of the piece; the sound is much better heard than in the open air. It is farther to be considered, what the event will prove, when the sound is not enclosed all the length of its way, but passes in part through open air; as when one speaks at some distance from a shooting trunk; or where the ear is at some distance from the other end of the trunk; or where both the mouth and ear are distant from the trunk. It has been found that in a trunk of eight or ten foot, the sound is helped, though both the mouth and the ear be four or five inches from the ends of the trunk: and somewhat farther assisted when the ear of the hearer, than when the mouth of the speaker, is near. And it is certain, that a voice is better heard within a chamber from without, than without from within the chamber. And as an entire enclosure preserves the sound, so does a semi-concave, though in a less degree. Therefore, if a person speak at one end of a half tube, or trunk, and you lay your ear to the other, this will carry the voice farther, than to speak in the air at large. Nay, if it be not a semi-concave; but the like be done along the mast of a ship, or the outside of a piece of ordnance

though this be on a convex surface, the voice will be heard farther than in the open air. It should be tried, how, and with what proportion of disadvantage, the voice will be carried in a horn, or an arched line; or in a trumpet, which is a retorted line; or in a pipe, that is sinuous.*

It is certain, that sounds are producible without air; though this be the most favourable medium thereof. For a pair of tongs opened and shut at some depth within water, may be heard without any great diminution of the sound; though there is no air at all present. Take one vessel of silver, and another of wood, fill each of them with water, and then strike the tongs together, as before, about four inches from the bottom; and the sound in the silver vessel will be much more resonant than in that of wood: yet if there be no water in the vessel, so that the tongs play in the air, there will be no difference between the sound coming from the silver or the wooden vessel. Whence, besides the capital point of producing sound without air, we may collect, that the sound communicates with the bottom of the vessel; and that such a communication passes better through water than air.

* There remain many experiments of this kind to be

Strike any hard bodies together, in the midst of flame; and the sound will differ little from the sound in air.

The pneumatical part, which is in all tangible bodies, and has some affinity with air, performs, after a sort, the office of the air: thus the sound of an empty barrel, is in part, created by the air on the outside; and in part, by that in the inside: for the sound will be less, or greater, as the barrel is more or less empty: though it communicates also with the spirit in the wood, through which it passes from the outside to the inside. So likewise in the chiming of bells on the outside; the sound passes to the inside.

It were gross to think, that the sound in strings is produced between the finger and the string: for these are but preparatories to the production of the sound, which is formed between the string and the air; and that not by any impulse of the air, from the first motion of the string; but by the return of the string (now strained by the touch) to its former place: which motion of return, is quick and sharp; whereas the first motion is soft, and dull. So the bow tortures the string continually, and thereby holds it in a constant trepidation.

SECT. III.

THE MAGNITUDE, SMALLNESS, AND DAMPS OF SOUNDS.

LET one person whistle at one end of a shooting trunk, whilst another holds his ear at the other end: and the sound will strike the ear so sharp as to be scarce tolerable: for sound naturally diffuses in a sphere, and so spends itself; but if made to go in a canal, it must needs acquire greater force. And thus enclosures not only preserve, but also increase and sharpen sounds.* A French-horn being greater at one end than at the other, increases the sound

* Does not this experiment give some light to the Bishop of Fern's first and second Problem; viz. 1. To make the least sounds, by the help of instruments, as loud as the greatest; a whisper to become as loud as the report of a cannon? and, 2. To propagate any, the least, sound to the greatest distance? Whoever understands the scope and tendency of the present enquiry, will not, perhaps, be at a loss to make several discoveries in phonics, intimated, but not divulged, by that learned prelate; and even to carry the doctrine of acoustics, diacoustics, and catacoustics, farther than his intimations reach. See Philosophical Transactions, 319. And consult Dr. Hook's Posthumous Works.

more than if the horn were of an equal bore: for the air and sound, being first contracted at the lesser end, and afterwards having more room to spread at the greater, dilate themselves; and in coming out strike more air, whereby the sound is rendered larger and deeper. And even hunters' horns, which are commonly made strait, not oblique as the former, are always greater at the lower end. It should be tried also in pipes, made much larger at the lower end: or with a belly towards the end, and then issuing in a strait concave again.

There is in St. James's fields a conduit of brick, with a low vault adjoining; and at the end of that, a round house of stone: in the brick conduit is a window; and in the round house, a small slit; so that when a person holloes in the slit, it makes a fearful roaring at the window. For all concaves that proceed from narrow to broad, amplify the sound at coming out.

Hawks-bells, that have holes in the sides, give a greater ring, than if the pellet struck upon brass in the open air. For the sound inclosed by the sides of the bell, comes out at the holes unspent, and stronger. And in drums, the closeness round about, that preserves the sound from dispersing, makes the noise come out at the drum-holes, much louder and stronger,

than if the like skin were struck, extended in the open air.

Sounds are heard better and farther in an evening, or in the night, than at noon, or in the day: because in the day, when the air is thinner, the sound pierces more; but when the air is thicker, as in the night, it spreads less: as being now in a degree of enclosure. It is true also, that the general silence of the night contributes to this effect.

There are two kinds of reflection in sound; the one at a distance, or the echo; wherein the original is heard distinctly, and the reflection also distinctly: the other in concurrence; when the sound reflecting near, returns immediately upon the original, and so repeats it not but amplifies. Whence music upon the water sounds sweeter; and better in chambers that are wainscotted, than such as are hung.*

The strings of a lute, viol, or virginal, give a much greater sound, on account of the knot and concavity beneath, than if there were only a flat board without that hollow and knot, by which

* These particulars deserve to be compared with those mentioned by the bishop of Ferns, in the paper so often cited; which may shew upon what foundation he proceeded to build his highly useful and extensive doctrine of acoustics.

the upper air communicates with the lower. An Irish harp admits the open air on both sides of the strings: and its belly runs not along with the strings, but lies at the end of them. It makes a more resonant sound than the bandora, orpharion, or cittern; though these have wire-strings as well as that. The cause seems to be, that the open air on both sides helps where there is a concavity; which is therefore best placed at the end. A virginal, when the lid is down, makes a slenderer sound than when the lid is up: for all shutting in of air, where there is no competent vent, damps the sound.

There is a church at Gloucester, (and I have heard the like of other places) where, if a person speaks softly against a wall; another shall hear his voice better, at a considerable distance, than near at hand:* enquire more particularly of the structure of that place.† I suspect there is some vault, or hollow, or isle, behind the wall; and some passage to it from the farther end of that wall, against which the person speaks; so that

* On this property of sound, arising from the structure of a place, may depend the bishop of Ferne's third and last problem; viz. to convey a sound from one place to another, at a great distance; so as that it shall not be heard in the middle.

† Consider the nature of whispering galleries, as particularly, at St. Paul's in London.

the voice slides along the wall, then enters at some passage, and communicates with the air of the hollow: for it is somewhat preserved by the plain wall; but that is too weak to give an audible sound, till it has communicated with the back air.*

Place the horn of the bow near your ear, then touch the string, and the sound will be encreased to a degree of tone: the sensory, in this case, by reason of the near approach, being struck before the air disperses. The like happens, if the horn be held betwixt the teeth: but this is a plain propagation of the sound from the teeth to the organ of hearing; for there is a great intercourse between these two parts; as appears from hence, that a harsh, grating tune sets the teeth on edge. The same thing happens if the horn of the bow be applied to the temples; the sound thus sliding from hence to the ear. If a rod of iron, or brass, be held with one end to the ear, and the other be struck upon, it makes a much greater sound than the same stroke upon the rod, when not so contiguous to the ear. By which, and other instances, it should seem that sounds do

* He who shall make himself master of the nature and properties of sounds, will, perhaps, have it in his power to perform as surprising things as Friar Bacon is said to have done, by his skill in optics, and, probably, more serviceable;

not only slide upon the surface of a smooth body; but also communicate with the spirits in the pores of the body.*

In Trinity-College, Cambridge, there was an upper chamber, weak in the roof, and therefore supported by an iron prop, as thick as a man's wrist, placed in the middle of the chamber: which iron, if struck, would make only a little flat noise in the room; but a great bomb in the chamber below. The sounds made by buckets in a well, when they strike against the sides, or plunge into the water, &c. are deeper and fuller than if the like percussion were made in the open air: on account of the confinement and enclosure of the air in the concave of the well. So empty barrels placed in a room under a chamber, make all the sounds in the chamber more full and resounding. Hence there are five general ways of encreasing sounds;† viz. 1. simple enclosure;‡ 2. enclosure with dilatation;§ 3. communica-

* Something to this purpose was intimated above, Sect. II. 7.

† Observe, with regard to the method of the enquiry, the use of particular instances and experiments; none of which are to be collected and made for their own sakes, but to furnish the means of induction, and axioms that lead to capital works.

‡ As in cylindrical tubes.

§ As in speaking trumpets, &c.

tion;* 4. approach to the sensory:† and 5. concurrent reflection.‡

With regard to exility of sounds; it is certain the voice passes through solid and hard bodies; if they be not too thick; and again, through water: but then the voice is, by such a passage, reduced to a great exility. Thus, if the holes of a hawk's bell be stopped, it will not ring; but rattle like the eagle-stone, which contains another stone within it. And as for water; take a pail, turn the bottom upward, and carry the mouth of it down to the level of the water; plunge it six inches deep, still keeping it even, that it may not tilt on either side, and so the air get out: then let a person dive so far under water, as to put his head into the pail; and there will come out as much air in bubbles as to make room for his head. Now let him speak, and his voice will be heard plainly; though now made extremely sharp, like the mock-voice of puppets; yet the articulate sounds of the words will not be confounded. It may be more commodious to put the pail over

* As in harps, &c. where the air communicates on both sides.

† As when the ear is close applied to the sounding body.

‡ As in speaking near hollow vessels, &c. Could not various particular methods, capable of producing great effects, be found, by an artificial application, or combination, of two or more of these?

a man's head above water; then, he sinking down, to press the pail down with him, so that by kneeling or sitting, he may be lower than the water.

In lutes, and stringed instruments, if you stop a string high, whereby it has less scope to tremble, the sound is more treble, but more dead. Take two saucers, and strike the edge of the one against the bottom of the other, within a pail of water; and as you put the saucers lower and lower, the sound will grow flatter, even while part of the saucer is above the water; but that flatness of sound is joined with a harshness, caused by its inequality; as coming from the parts of the saucer that are under the water. But when the saucer is wholly under the water, the sound becomes clearer, though much lower; as if it came from afar.

Soft bodies damp sound much more than hard ones. Thus, if a bell be wrapped round with cloth or silk: it deadens the sound more than if the bell were surrounded with wood. Trial was made in a recorder, and varied several ways: the bottom of it was stopped, 1. with wax, 2. set against the palm of the hand, 3. against a damask cushion, 4. placed in sand, 5. placed in ashes, and 6. set half an inch deep in water, close to the bottom of a silver bason; and still the tone remained: but when the bottom of it was set

against, 1. a woollen carpet, 2. a plush lining; 3. a lock of wool, though loose; and, 4. against snow, the sound of it was quite deadened, and no more than a breath.

Hot iron produces not so good a sound as cold; for, while hot, it appears to be more soft, and less resounding. So likewise, warm water in falling, makes not so full a sound as cold; being, I conceive, softer, and nearer the nature of oil; for it is more slippery, and scours better.

Let a recorder be made with two fipples, at each end one; the trunk as long as two recorders, and the holes answerable towards each end: let two persons play the same lesson upon it in unison; and observe whether the sound be confounded, or augmented, or deadened. So likewise, let a cross be made of two hollow trunks; and let two persons speak, or sing, the one lengthwise, the other transverse: and let there be two hearers at the opposite ends; to observe whether the sound be confounded, augmented, or deadened. These two instances will also give light to the mixture of sounds.*

* Perhaps these two experiments have not hitherto been tried; at least, I have not met with them in any other author; though, possibly, the bishop of Ferns knew their success; if we may conjecture from his intimation of an uncommon method of mixing sounds; and making a concert with a single instrument. Let the nature and application of echo-

Bellows being blown in at the hole of a drum, whilst the drum beats, makes it sound a little flatter, without any other apparent alteration. The cause is, that the bellows in part prevent the issuing of the sound; and in part also make the air less moveable.

SECT. IV.

OF THE LOUDNESS OR SOFTNESS OF SOUNDS, AND THEIR PROPAGATION TO LONGER OR SHORTER DISTANCES.

THE loudness and softness of sounds, is a thing distinct from their magnitude and exility; for a bass string, though gently struck, gives the greater sound; but a treble string, if hard struck, will be heard much farther: because the bass string strikes, more air, and the treble less, but sharper. The strength of percussion is, therefore, a principal cause of the loudness and softness of sounds; as in knocking harder or softer; winding a horn stronger or weaker, &c. And the strength of this percussion consists as much in the hardness of the body struck, as in the force of the striking

ing and whispering places, be considered upon this occasion But, for the mixture of sounds, see more hereafter, Sect XVI.

body: for if you strike cloth, it gives a less sound; if, with the same force, wood a greater; if metal, a still greater. And, in metals, gold gives the flatter sound; and silver, or brass, the more ringing sound. But air, where strongly confined, resembles a hard body: whence the loud noise in discharging a cannon. We find also, that a charge, whether with bullet, or paper, wet and hard stopped, or with powder alone, rammed hard, makes no great difference in the loudness of the report.

The sharpness or quickness of the percussion, is a great cause of the loudness, as well as the strength. So if you strike the air with a whip, or a wand, the sharper and quicker it is done, the louder sound it makes. And in playing upon the lute, or virginal, the quick touch adds great life to the sound: the quick stroke cutting the air suddenly; whilst the soft one rather beats than cuts it.*

* See this article farther prosecuted in Mr. Malcolm's Treatise of Music, Chap. I. and M. Perault's Essais du Bruit. There are also certain papers in the Philosophical Transactions, and French Memoirs, that give light to this subject.

SECT. V.

OF THE COMMUNICATION OF SOUNDS.

AN apt experiment for demonstrating the communication of sounds, is the chiming of bells; for if you strike with a hammer, first upon the upper part of the bell, then upon the middle, and lastly upon the lower part; you will find the sound to be more treble or more bass, according to the concavity on the inside; though the percussion be only on the outside.

When the sound in wind-instruments is produced between the blast of the mouth, and the air of the instrument, it has yet some communication with the matter of the sides of the instrument, and the spirits therein contained; for in a flute, or trumpet of wood and another of brass, the sound will be different: so if the flute be covered with cloth or silk, it gives a different sound from what it would do of itself; and if the flute be a little wet on the inside, it will make a different sound from the same flute dry.*

* Some particulars relating to this article, have been already treated occasionally, under Sect. III.

SECT. VI.

OF THE EQUALITY AND INEQUALITY OF SOUNDS.

WE come next to such inequality of sounds as proceeds, not from the nature of the bodies themselves, but is accidental; either through the roughness or obliquity of the passage, the doubling of the pecutient, or the trepidation of the motion. A bell if cracked, whereby the sound has not a clear passage, rings hoarse and jarring; so the human voice, becomes hoarse, when by a cold the wind-pipe grows rugged and furred. And in these two instances the sounds are ungrateful, because totally unequal; but when unequal in equality, they prove grateful, though purling.

All instruments that have either returns, as trumpets; flexures, as cornets; or are elevated and depressed, as sackbuts; yield a purling sound: but the flute, that has none of these inequalities, gives a clear sound. Yet the flute itself moistened a little on the inside, sounds more solemnly, and with a degree of purling or hissing. And a wreathed string, such as the bass strings of a bandora, also yields a purling sound.

But a lute-string, if it be altogether unequal in its parts, gives a harsh and untuneable sound; which kind of strings we call false strings, as being bigger in one part than another: whence wire-strings are never false. So, to try a lute-string, we extend it hard between the fingers, and fillip it; and if it give a double species, it is true; but if more, it is false.*

The running of waters affords a trembling noise; and in regals, which have a nightingale-pipe that contains water, the sound is continually tremulous. There is also a play-thing for children called cocks,† with water in them; which, when blown into, yield a trembling sound: and this trembling of water has an affinity with the letter L. And all these inequalities of trepidation are rather pleasant than otherwise.

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* I suppose this double species is meant of the two sensations, or sounds, caused by the going, and returning of the string, which sounds will only be uniform, or equable, when the string is of the same thickness in all the vibrating parts.

† The thing here meant, seems at present to be out of use: it is a kind of bellied-whistle, made of earthen-ware, and filled with water up to the whistle-part; whereat, when a person blows, it yields a shrill, or very harsh sound, with a considerable degree of purling. By purling, is understood, what may be otherwise called the jug, or quick double; as in the singing of the nightingale, the playing of a flagellet, &c.

All bass, or very treble notes, give a rough sound; the bass striking more air than it can well strike equally: whilst the treble cuts the air so sharp, that it returns too swift to make the sound equal; and therefore the mean, or tenor, is the sweetest part in music.

We know nothing that can, at pleasure, make a musical or immusical sound, by voluntary motion, but the voice of man and birds. The cause is, no doubt, in the windpipe; which, being well extended, acquires an equality; as a bladder that is wrinkled, becomes smooth when extended.* The extension is always greater in tones than in speech; whence the inward voice, or whisper, can never give a tone. And in singing, there is a greater labour of the throat than in speaking; as appears from the thrusting out, or drawing in of the chin, when we sing. The humming of bees is an unequal buzzing, conceived, by some of the ancients, not to issue at the mouth of the creature; but to be an inward sound. It should rather seem to proceed from the motion of their wings; for it is not heard but when these stir.

All metals quenched in water give a hissing sound; (which has an affinity with the letter Z;) notwithstanding the sound is created between the

* There is a curious paper to this purpose in the French Memoirs.

water, or vapour, and the air. Boiling also, if there be but little water in a vessel, makes a hissing sound; but boiling in a full vessel makes a bubbling sound, somewhat like that of the cocks used by children.*

Trial should be made, whether the inequality of the medium will not produce an inequality of sound; as if three bells were made, one within another, with air between them; and the outermost bell were chimed with a hammer; how would the sound differ from that of a single bell? so, likewise, join a plate of brass, and a plank of wood together; and strike upon one of them, to try if they do not give an unequal sound. Again, make two or three partitions of wood in a hogshead, with holes or knots in them; and mark the difference of their sound from that of a hogshead without such partitions.†

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* See p. 91.

† He who desires to improve the present set of musical instruments, or to invent new ones, with advantages wanting in the present, should apply to the making of these kinds of experiments; without which, no just axioms in physics, capable of directing the instrument-maker, can be procured.

SECT. VII.

OF THE MORE TREBLE, AND THE MORE BASS TONES, OR MUSICAL SOUNDS.

'Tis evident that the percussion of a great quantity of air, causes the bass sound; and the less quantity, the treble. The percussion of the greater quantity of air, proceeds from the largeness of the striking body, and the length and breadth of the concavity through which the sound passes: whence a bass string is greater; a bass flute, wider than a treble; and in pipes, and the like, the lower the note-holes are, and the farther from the mouth of the pipe, the more bass the sound; and the nearer the mouth, the more treble: so, if you strike an entire body, as an handiron of brass, at the top, it makes a more treble sound; and at the bottom, a more bass. 'Tis also evident, that the sharper or quicker percussion of the air, causes the more treble sound; and a slower, or heavier, the more bass sound. So in strings, the more they are strained, the quicker they start back, and the more treble the sound; as, on the contrary, the slacker they are, the baser the sound: and hence, a bigger string more stretched, and a smaller string less stretched, may fall into the same tone.

'ildren, women, and eunuchs, have smaller,

and shriller voices than men; not because men have greater heat, which may make the voice stronger (for strength of voice regards only loudness and softness, not tone;) but from the dilatation of the organ, which indeed, may proceed from heat. But the cause of changing in the voice, at the years of puberty, is more obscure. It seems to be hence, that when much of the moisture of the body, which before watered the parts, is drawn down to the spermatic vessels, it leaves the body hotter; whence the dilatation of the organs:* for all the effects of heat manifestly come on at this time; as pilosity, roughness of the skin, hardness of the flesh, &c.

The industry of musicians has invented two other ways of straining strings, besides winding: the one is, stopping them with the finger, as in the neck of lutes, viols, &c. the other is, by shortening the strings, as in harps, virginals, &c. Both these depend upon the same principle, as they on-

* Viz. the Aspera Arteria, or the head of the larynx, &c. and we certainly know that heat has the power of dilating, or expanding all the parts of the body, as well as rendering them dry. And, doubtless, these two properties have a power of altering sounds, as all instances confirm. However, the point should be more accurately stated by philosophical anatomists.

ly cause the string to give a quicker start. In straining of a string, the farther it is stretched the less super-straining goes to a note; for a string requires to be considerably wound, before it will make any note at all: and in the stops of lutes, &c. the higher they go, the less distance there is between the frets.

If you fill a conical drinking-glass with water, then fillip it on the brim, and afterwards empty part of the water, and so more and more; still trying the tone by fillipping, you will find the tone more bass, as the glass is more empty.

SECT. VIII.

OF THE PROPORTION OF TREBLE AND BASS TONES.

THE just, and measured proportion of the air struck, with regard to the baseness, or trebleness of tones, is one of the greatest secrets in the contemplation of sounds; for it discovers the true coincidence of times into diapasons; which is the return of the same sound; and so of the concords and discords between the unison and the diapason. This may be discovered, 1. in the proportion of the winding of strings: 2. in the proportion of the distance of frets; and, 3. in the proportion of the concavities of [illegible]s, &c. but more commodiously in the

But first try the winding of a string once about, as soon as it is brought to that extension as to give a tone, then twice about, thrice, &c. and mark the scale, or difference of the rise of the tone: whereby, you will, at once, discover two effects, or the proportion of the sound, in respect to winding: and the proportion of the sound, in respect of the string, as it is more or less strained; but to measure this, the way will be, to take the length in a right line of the string, upon any winding about of the peg.

As for the stops: take the number of frets; and, principally, the length of the line from the first stop of the string, to such a stop as shall produce a diapason to the former, upon the same string.

But, as we before observed, the thing will best appear in the bores of wind-instruments: let, therefore, six pipes be made alike, in length and all things else; only with a single, double, and so on to a sextuple bore; and mark what fall of tone every one gives. But in these three instances it must be diligently observed, what length of string, distance of stop, and concavity of instrument, gives what rise of sound: thus, in the last case, you must set down what increase of concavity goes to the making of a note higher,

what of two notes, what of three; and so up to the diapason: for then the great secret of numbers and proportions will appear. Perhaps the makers of wind-instruments know this already; because they make them in sets: and likewise bell-founders, in adjusting the tune of their bells: so that enquiry may here save trial.*

'Tis observed by one of the ancients, that an empty barrel struck with the finger, gives a diapason to the sound of the like barrel when full; but how that should be, I do not well understand; because the striking of a barrel, full or empty, scarce gives any tone.†

Some sensible difference is required in the proportion of creating a note, with regard to the sound itself, which is passive; and that it be not too near, but at a distance: for in a recorder, the three uppermost holes yield one tone; which is a note lower than the tone of the first

* It should seem, that the makers of wind instruments, and bell-founders, have no exact rule for this purpose; or else no true method of observing it: they, however, come tolerably near, by habit and practice, as it were mechanically; and afterwards by making some small alterations as scraping the pipe, or chipping the bell, bring the tone to a truth.

† Perhaps the vessel was not of wood, but metal. How does the thing succeed in glass? See above, Sect. VII.

three: and the like, no doubt, is required in the winding or stopping of strings.*

SECT. IX.

OF EXTERNAL AND INTERNAL SOUNDS.

THERE is another difference of sounds, which we call external and internal. There is neither soft nor loud, bass nor treble; musical nor immusical: and though there can be no tone in an external sound, yet it may be both musical and immusical. The internal sound we mean, is rather an impulse or contrusion, than an elision, or cutting of the air; so that the percussion of the one, with regard to the other, differs as a blow does from a cut. In speech, the whisper, whether loud or soft, is an internal; but speaking out, an external sound; whence we can never make a tone, nor sing in whisper; but in speech we may. So breathing, or blowing by the mouth, bellows, or wind, though loud, is an internal sound; but the blowing through a pipe, or concavity, is an external one. So likewise, the greatest winds, if they have no coarctation, or blow not hollow, give an internal sound; but the

* There seems to be something intimated here, with regard to the creation of notes, that has not hitherto been clearly and physically made out.

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whistling, or hollow wind, yields a singing, or external sound; the former being confined by some other body; and the latter, confined by its own density; and therefore when the wind blows hollow, 'tis a sign of rain. So flame, as it moves within itself, or is blown by bellows, gives a murmur, or internal sound.

There is no hard body, but when struck against another hard body, will yield an external sound, greater or less: insomuch, that if the percussion be over-soft, it may induce a nullity of sound; but never an internal sound: as when one treads so softly as not to be heard. Where the air, whether confined or not confined, is the percutient against a hard body, it never gives an external sound; as in blowing strongly with bellows against a wall. Sounds, both external and internal, may be made as well by suction as by emission of the breath, as in whistling or breathing.*

SECT. X.

OF THE ARTICULATION OF SOUNDS.

'Tis one of the greatest mysteries in sounds, that the whole sound is not only in the whole

* This article remains considerably defective.

air; but the whole sound is also in every small part of the air: so that all the curious diversity of articulate sounds, as in the voice of a man or birds, will enter at a small chink, without confusion.

The unequal agitation of the winds, or the like, though it promotes the conveyance of sounds; yet does not confound their articulation, within the distance they can be heard to; though it may cause them to be heard the less way.*

Too great distance confounds the articulation of sounds: thus we may hear the sound of a preacher's voice, when we cannot distinguish what he says. And one articulate sound will confound another; as when many speak at once.

In speaking under water, when the voice is reduced to an extreme exility;† yet the articulate sounds, that is the words, are not confounded. I conceive, that an extreme small, or an extreme great sound, cannot be articulate; but that articulation requires a mediocrity of sound; as the extreme small sounds confound the articulation by contracting; and the large one by

* See Mr. Derham's latin paper upon the motion of sounds, in the Philosophical transactions, No. 313.

† See above, Sect. 3.

dispersing. And though an articulate sound already created, will be contracted into a small compass, and pass through a narrow chink; yet the first articulation requires a greater dimension.

It has been observed, that in a room, or chapel, vaulted below and above, a preacher cannot be heard so well, as in the like places, not so vaulted. For in this case the subsequent words come on, before the precedent ones vanish: and therefore the articulate sounds are more confused, though the gross of the sound be greater.

The motions of the tongue, lips, throat, palate, &c. which go to make the several alphabetical letters, relate to the enquiry of sounds. The Hebrews have been diligent herein: and determined which letters are labial, dental, guttural, &c. The Latins and Grecians have distinguished between semi-vowels and mutes; and in mutes tolerably well between mutæ tenues, mediæ & aspiratæ: though not with diligence. For, they have little examined the particular percussions and motions that create those sounds: as that the letters, B, P, F, M, are not expressed, but with contracting or shutting the mouth; that the letters N and B, cannot be pronounced together, without the letter N turning into M: As Hecatonba will become Hecatomba: That nd T cannot be pronounced together, but P

will come between them; as Emtus is pronounced Emptus: and there are many of the like instances. So that whoever enquires to the full, will find, there are fewer simple motions required, to the making of the whole alphabet, than there are letters.*

The lungs are the most spungy part of the body, and therefore ablest to contract and dilate; and when they contract, they expel the air; which passing through the aspera arteria, throat, and mouth, makes the voice: but articulation is not produced without the help of the tongue, the palate, and the rest of those called the organs of speech.

There is a similitude between the sound made by inanimate bodies, or animate bodies that have no articulate voice; and several letters of articulate voices: and men have commonly given such names to these sounds, as allude to the articulate letters. Thus the trembling sound of water bears a resemblance to the letter L; the quenching of hot metals, in water, to the Letter Z; the snarling of dogs, to the letter R; the

* This is a curious part of the enquiry, and of large extent; which some make a part of grammar or speech: tho' it requires a physical consideration. Let Dr. Holder, Dr. Wallis, Mr. Amman, the Philosophical Transactions, and the French Memoirs, be consulted upon this occasion.

voice of screech-owls, to the letters Sh; the voice of cats, to the diphthong Eu; the voice of cuckows, to the diphthong Ou; the sounds of strings, to the letters Ng. So that for instance, to make an inanimate body pronounce a word; the motion of the instruments of the voice must be considered, on the one side; and the like sounds made in inanimate bodies, on the other; and what conformity causes the similitude of sounds.*

* Were it not hence easy to make a dog, a cat, or other creature pronounce certain words distinctly? And is there any other secret in the accounts we have had of speaking dogs, than that the master knew how to make them growl, or howl in one continued tone, whilst he modulated the sound with his hand, by directing the motion of the dog's mouth, so as to render the voice articulate? And if this general enquiry were to be duly prosecuted, no doubt, but even inanimate bodies, however strange it may seem, might be made to speak certain words. And whoever shall thoroughly understand the nature of sounds, will be able to do much greater things than these. For such things only appear strange through our own ignorance.

SECT. XI.

THE DIRECTION OF SOUNDS.

SOUNDS move in a sphere; that is, every way; upwards, downwards, forwards and backwards; as appears in all instances. Sounds do not, like the rays of light, require to be conveyed to the sense in right lines; though they move strongest in a right line: because such a line is the shortest distance. Hence, a voice on one side of a wall is heard on the other: not because the sound passes through the wall; but arch-wise over it.

If a sound be stopped, and repelled, it goes round on the other side; in an oblique line. Thus, if a bell be rung on the north side of a chamber, and the window of that chamber open to the south; a person within the chamber would think the sound came from the south; and the case is the same in a coach, &c.

Sounds, though they move in a sphere, yet are strongest, and go farthest in the front-line, from the first impulse of the air; and therefore, in preaching, the voice is better heard before the pulpit, than behind it, or on the sides; though

it stand open. So a piece of ordnance will be farther heard forward from the mouth of the piece, than behind, or on the sides.*

It may be suspected, that sounds move better downwards than upwards. Pulpits are placed high above the people: and when the ancient generals harangued their armies, they had always a mount cast up, for them to stand upon. But this may be imputed to the stops and obstacles, which the voice meets with, in speaking on a level. Yet there seems to be somewhat more in it; for perhaps spiritual species, both visible and audible, move better downwards than upwards.† It is strange, that to men standing upon the ground, others upon the top of St. Paul's, seem not only much less, but cannot be known; whilst to those above, the persons below seem not so little, and may be known: though all other things to them above, seem somewhat contracted, and better defined, or collected into figures.‡ So knots in gardens shew best from an upper window or terrace. But to make an exact trial, with regard to sound, let a man stand in a chamber

* See Mr. Derham's Experiments in the Philosophical Transactions.

† This may hold true of sounds, because of the greater density of the air below than above: but will it hold true of vision, for the same reason?

‡ Is the observation verified?

not much above the ground ;* and speak out at the window through a trunk, as softly as he can, to one standing on the ground ; the other laying his ear close to the trunk : then let the person below speak, in the same degree of softness ; and let him in the chamber lay his ear to the trunk : and this may be a proper means to judge whether sounds descend or ascend the better.

SECT. XII.

THE DURATION OF SOUNDS ; AND THE TIME THEY REQUIRE IN THEIR GENERATION, OR PROPAGATION.

AFTER sound is created, as it is in a moment, we find it continues some small time, melting by degrees. And here a great error has prevailed, in taking this to be a continuance of the first sound ; whereas it is a renovation : for the body struck has a trepidation wrought in the minute parts ; and so renews the percussion of the

* Why should not the experiment be tried at a greater height from the ground ; if a long tube were procurable ? What is the common observation of masons, working on the top of a steeple, and conversing with others below ?

air. This is evident; because the melting sound of a bell, or string, ceases as soon as the bell or string is touched, And here are too trepidations to be distinguished: the one manifest and local: as of the bell when it is pensile: the other secret, and of the minute parts:* yet the local greatly helps the secret one. So likewise in pipes, and other wind-instruments, the sound lasts no longer than the breath blows. It is true that in organs there is a confused murmur for a small time after; but this is only while the bellows are falling.

It is certain, that the report of ordnance, where many are fired together, will be carried above twenty miles by land: and much farther by water: but then it comes to the ear, not in the instant of shooting; but perhaps an hour or more after:† which must needs be a continuance of the first sound: for there is no trepidation to renew it. And the touching of the ordnance would not extinguish the sound the soon-

* This distinction is made great use of by M. Perault, in his Essais du Bruit.

† The velocity of sound is somewhat differently computed by different authors. According to Mr. Boyle it moves 1200 English feet in a second; and according to Dr. Halley 1142. See Newton. Princip. Lib. II. Prop. 50. And again, Mr. Derham's Paper in the Philosophical Trans- No. 313.

er: so that in greater sounds, the continuance is more than momentary.

To try exactly the time wherein sound is propagated; let a man stand in a steeple, with a taper, veiled; and let another man stand a mile off: then let the person in the steeple strike a bell; and at the same instant withdraw the veil or blind, that the other at a distance may measure the time between the light seen, and the sound heard: for light is propagated instantaneously.* This may be tried in far greater distances; allowing greater lights and sounds.

It is generally observed, that light moves swifter than sound; for the flash of a musket is seen sooner than the report is heard. And in the hewing of wood, we may see at some distance, the arm lifted up for a second stroak, before we hear the sound of the first. And the greater the distance, the greater is the anticipation: as in thunder afar off; when the lightning long precedes the crack.†

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* Or what comes very near thereto: for in the space of seven or eight minutes, it is thought by some to travel from the sun to the earth. See Newton. Princip. Lib. II. Prop. 96. Schol.

† On this foundation the distance of explosions, thunder, &c. may be readily known; by counting the seconds that pass betwixt the flash and the report.

Colours represented to the eye, neither fade, nor melt by degrees; but appear still in the same strength; whilst sounds melt and vanish by little and little: for colours participate not of the motion of the air; as sounds do. And it is manifest that sound participates of some local motion of the air; because it perishes so suddenly: for in every division or impulse of the air, the air suddenly restores and re-unites itself; which water also does, though not so swiftly.

SECT. XIII.

THE PASSAGE AND INTERCEPTION OF SOUNDS.

In experiments of the passage, or resistance of sounds, care must be had not to mistake the passing along the sides of a body, for the passing through a body: and therefore the intercepting body should be very close; for sound will pass through a small chink. But when the sound is to pass through a hard or close body; as a wall, metal, water, &c. the body must be but thin and small; otherwise it utterly damps the sound: whence in the experiment of speaking under

water, the voice must not be very deep within the water; for then the sound would not penetrate through.

It is certain, that in the passage of sounds through hard bodies, the spirit or pneumatical part of the body itself, co-operates;* but much better when the sides of the hard body are struck, than when the percussion is only internal, without touching the sides. Take, therefore, a hawk's bell, with the holes stopped up; and hang it, by a wire, within a glass bottle; close the mouth of the glass with wax; then shake the glass, and try whether the bell will give any sound, or how weak.†

It is certain, that a very wide arch descending sharp, will quite extinguish sounds; so that the sound which would be heard over a wall, cannot be heard over a church; nor the sound, audible at some distance from a wall, be heard close under the wall.

Soft and foraminous bodies will deaden sounds in their first creation; for the striking against

* This is more fully insisted upon above, Sect. III.

† The invention of the air-pump and condensor has rendered numerous experiments, with relation to sounds and hearing, much more commodiously practicable, than they could have been without it. But philosophers seem weary of these new engines already; before half their uses are known.

cloth or fur makes little sound; but in its passage, they admit it better than harder bodies: so curtains and hangings do not stop a sound much; but glass windows, if very close, will check it more than the like thickness of cloth.

It is worth enquiring, whether great sounds do not become more weak and exile, in passing through small chinks: for the subtilties of articulate sounds may perhaps pass them unconfused; but magnitude of sound not so well.*

SECT. XIV.

OF THE MEDIUM OF SOUNDS.

THE mediums of sounds are air, water, soft and porous bodies; and in some degree also, hard ones: but all of them are dull and unapt, except the air. The thinner air does not convey sound so well as the denser. This appears from sounds in the night and evening; in moist weather, and in southern winds: for thin air is better penetrated; whilst a thick air better preserves the sound from waste. But let farther trial be made, by hollowing in mists and gentle showers:

* See Sect. X.

for dampness, perhaps, will somewhat deaden the sound.*

How far flame may be a medium of sound; especially such as are created by air, and not betwixt hard bodies; may be tried by speaking where a bonfire is between: but then allowance must be made for some disturbance in the sound, caused by that of the flame itself.

Whether any other fluids, being used as mediums, propagate sound differently from water, may be easily tried; as by striking the bottom of a vessel, filled either with milk, or oil; which, though more light, are more unequal bodies than water.†

SECT. XV.

OF THE FIGURES OF THE CONCAVES, OR BODIES THROUGH WHICH SOUNDS ARE CONVEYED.

THE figure of a bell partakes of the inverted, truncate pyramid; but comes off and dilates more suddenly. The figure of the huntsman's horn, and cornet, is oblique; though there are likewise strait horns; which if of the same bore with the

* See Mr. Boyle's Pneumatical Experiments relating to sounds.

† This article also remains but imperfectly prosecuted.

crooked ones, differ little in sound; though the strait ones require a somewhat stronger blast. The figures of recorders, and pipes, are strait; but the recorder has a less bore above; and a greater below. The trumpet has the figure of the letter S,* which makes the purling sound, &c. Generally the strait line makes the clearest and roundest sound; and the crooked the more hoarse and jarring.

Trial should be made with a sinuous pipe, having four flexures: as also with a pipe made in the form of a cross, and open in the middle; and again with an angular pipe: to see what would be the effects of their several sounds. Try likewise a circular pipe; made perfectly round, with a hole to blow in; and another not far from that; but with a tranverse, or stop between them; so that the breath may go the round of the circle, and issue at the second hole.†

Percussions may be likewise tried in solid bodies of several figures; as globes, flats, cubes, crosses, triangles, &c. and their combinations; as flat against flat, convex against convex, con-

* Some trumpets have a circular turn in the middle.

† Is not this the structure of the little round horn or pipe used by the postillions in Germany; which gives a very odd sound, not to be described by words; being a kind of mixture of shrillness, loudness, and stops, somewhat reseling the braying of an ass?

vex against flat, &c. to shew the diversities of the sounds they produce. Try also the difference of sounds in several thicknesses of hard bodies, when struck. I have tried, that a bell of gold yields an excellent sound; not inferior to one of silver or brass, but rather better:* yet a piece of gold coin, sounds much flatter than a piece of silver.

The harp has its concave running cross-wise to the strings; and no instrument yields so melting and prolonged a sound as the Irish harp.† So that if a virginal were made with a double concave; the one all the length, as the virginal has; the other at the end of the strings, as the harp has; it might make the sound more perfect, or not so shallow and jarring. It may be tried without any sound-board along; but only harp-wise at one end of the strings: or lastly, with a double concave; one at each end of the strings.‡

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* Was the gold pure, or alloyed? one would not expect that so soft a metal as pure gold, should ring clear and strong.

† Observe, that the Irish harp has metalline strings; and is played with the nails, not the ends of the fingers, as the Welch harp is, the strings whereof are gut.

‡ What is the new contrivance practised in upright harpsichords? these experiments are of the same kind with those recommended above, Sect. VIII. and regard the improvement of musical instruments.

SECT. XVI.

OF THE MIXTURE OF SOUNDS.

THERE is an apparent diversity between visible and audible species, in this; that the visible do not mix in the medium; but the audible do: for we can see a number of trees, hills, men and beasts, at once: without the one confounding the other: but if so many sounds came from several parts, they would utterly confound each other. Thus voices, or concerts of music make harmony by mixture,* which colours do not. It is true, indeed, that a great light drowns a smaller; as the sun does that of a glow-worm; and a great

* Is it not the excellence of concerts, and the beauty, or perfection of harmony, to have the sounds of different instruments perfectly embodied as it were, or mixed together, like the different colours of light, so as to strike the ear with one compound sensation, as if it came from a single instrument, like light from the sun? and if so; could not ways be contrived, by some particular structure of the music-room, or Opera House, to incorporate these sounds; before they came to the ears of the audience? and by a suitable contrivance of this kind, might not a Dutch or an English concert be rendered as agreeable as an Italian one? See the next paragraph below.

sound drowns a less. So likewise, if there were two glass lanthorns, the one of a crimson colour, the other of an azure, and a candle were included in each; I suppose these coloured lights would mix and cast a purple colour upon white paper.* And even colours yield a faint and weak mixture; for white walls make rooms more lightsome than black. But the confusion in sounds, and the distinctness of visible objects proceeds from hence, that the vision is made in right lines, by means of several distinct cones of rays; whence there can be no coincidence in the eye, or visual point: whereas sounds, that move in oblique and crooked lines, must needs meet and disturb one another.†

The sweetest and best harmony is made, when every part, or instrument is not heard by itself, but a general consent of them all; which requires the audience to be at some distance: after the same manner as the mixture of perfumes is received; or the smells of several flowers in the air.‡ The disposition of the air, as to other qualities, unless joined with sound, has no great

* Sir Isaac Newton has many particulars relating to this subject, both in his Optics and Principia.

† See this matter farther cleared up by Sir Isaac Newton. Princip. Lib. II. Prop. 50. Schol.

‡ This comparison seems very well to explain the nature of concert. See the note upon § 1. above.

effect upon sounds: for whether the air be light or dark, hot or cold, in silent motion, or at rest, sweet or fetid, &c. this can make only some petty alteration: but sounds disturb and alter one another; sometimes by drowning, sometimes by jarring and discording, and sometimes by confounding with each other; and sometimes the one mixes and compounds with the other, and makes harmony.*

Two voices of the same loudness will not be heard twice as far as one of them alone; and two candles of equal light, will not render things visible twice as far as one. The cause lies deep; but it should seem that the impressions from the objects of the senses mix respectively, every one with its kind; but not in proportion: the reason may be, that the first impression, which is from privative to active, as from silence to noise, or from darkness to light, is a greater degree, than from less noise to more noise, or from less light to more light. The reason of this again may be, that the air after it has received a charge, does not receive a greater charge, with the same appetite, as at first. But to determine, the increase

* Is this strictly and fully explained by Sir Isaac Newton's doctrine of sounds; which makes them no more than propagated pulses of the air, proceeding from tremulous bodies? See Princip. Lib. II. Prop. 50.

of virtues, in proportion to the increase of matter, is a large field, that requires a particular treatment.*

SECT. XVII.

OF THE MELIORATION OF SOUNDS.

ALL concurrent reflections make sounds greater; but if the body that gives the original sound, or the reflection, be clean and smooth, it makes them sweeter. Trial may be made in a lute or viol, with the belly of polished brass, instead of wood; we find even in the open air, that the wire string is sweeter than the gut-string.† And for reflection, water excels: as we find in music near a river; and in echoes. It has been tried, that a pipe a little moistened on the inside, yet so as

* This is a subject that seems properly to fall under mathematical consideration; after particular experiments have been made. Something considerable is done in this way by Galileo, Sir William Petty, and others in a few subjects: but the design has by no means been extended to all sorts of virtues, powers, and effects, as it deserves; particularly in odours, electrics, magnetics, menstruums, &c.

† This is not judged so by all ears; though possibly a gut-string cannot be made so smooth and even as the wire-string.

to leave no drops, makes a more solemn sound, than if the pipe were dry; yet with a sweet degree of purling: for all porous things, by being moist, or, as it were, in a state between dry and wet, become a little more even and smooth: but the purling, which proceeds from inequality, I take to be caused between the smoothness of the inward surface of the pipe, which is wet; and the rest of the wood of the pipe, to which the wet does not reach.*

Music within doors, sounds better in frosty weather; perhaps not so much from the disposition of the air, as of the wood or string of the instrument; which is thus made more crisp, and thence more porous or hollow: and we find that old lutes sound better than new ones, for the same reason; so do lute-strings that have been long kept.†

Sound is likewise meliorated by the mixing of

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* It may perhaps be a contradictory instance to these, that the sound of an ivory hautboy is not sweeter than one of wood. And both in this, and all other enquiries, the contradictory instances should be sought with as much diligence as the concurrent; if we desire to come at the forms of things.

† It might deserve to be tried, whether false strings becoming true by keeping, as they have been found to do, acquire an equal thickness, in their parts, which they had not before.

open air, with confined air. Trial, therefore, may be made of a lute, or viol, with a double belly; and another belly with a knot over the strings; yet so as to leave scope enough for the strings to play below that belly. Trial may be likewise made of an Irish harp, with a concave on both sides: though perhaps it might thus resound too much; whereby one note would overtake another. To sing in the hole of a drum, makes the voice sweeter. So I conceive it would, if a song in parts, were sung in at several drums: and for elegance sake, there might a curtain be drawn between the drums and the audience.

The sound created in a wind-instrument, between the breath and the air, is meliorated, by communicating with a more equal body of the pipe: for there would doubtless be a different sound in a trumpet or pipe of wood; from that of a trumpet or pipe of brass. It were proper to try the effects of brass recorders, and brass horns.*

Sounds are meliorated by the intension of the sense, whilst the other senses are collected to the particular sense of hearing, and the sight sus-

* By what physical means is the sound of a violin made to resemble that of a drum, a hautboy, the French-horn, the bag-pipe, the organ, &c. as in a skilful hand it does to great exactness.

pended: whence sounds are sweeter in the night, than in the day; and I suppose sweeter to blind men than to others. And it is found, that between sleeping and waking, when all the senses are bound, music is far sweeter, than when one is full awake.*

SECT. XVIII.

OF THE IMITATION OF SOUNDS.

IT is strange, when attentively considered, how children, and some birds learn to imitate speech. They take no notice at all of the motion of the mouth; for birds are as well taught in the dark as by light. The sounds of speech are very curious and exquisite: whence one would think it were a lesson hard to learn. It is true, it is conquered with time, by degrees, and with many trials; but all this does not solve the wonder. It would almost make one think there is some transmission of spirits; and that the spirits of the teacher put in motion, work with the spirits of

* All the other ways of meliorating sounds should be here enumerated. Consider the use of sound-boards; and their best figure; a proper one to place behind the actors upon the stage, that may meliorate the voices, and convey them better to the pit and galleries, &c.

the learner, a pre-disposition to imitate; and so to perfect the imitation by degrees.* And for imitation, it is certain, there is in men and other creatures, a pre-disposition to imitate. How readily do apes and monkies imitate all the motions of men? and in the catching of dottrels, we see how the foolish bird plays the ape in gestures; and no man, in effect associates with others, but he learns unawares some of their gesture, voice, or manner.

In the imitation of sounds, it is not necessary that man should be the teacher: for birds will learn of one another; without any reward, as by feeding, or the like, given them in way of encouragement. Besides, parrots will not only imitate voices, but laughing, knocking, the squeaking of a door, or a cart-wheel; and any other noise they hear.†

No brute can imitate the speech of man; but only birds: for the ape, that is otherwise so ready to imitate, attains not to any degree of

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* See the articles Imitation and Sympathy.

† The stories related of parrots, are some of them very extraordinary; but scarce any more remarkable than that insisted upon by Mr. Locke, in his Essay upon Human Understanding; where the parrot seemed not only to speak distinctly, but to hold a dialogue rationally; and appositely imitated the cluck of a hen, in using the human voice.

speech; though there are dogs, which if a person howl in their ear, will fall a howling, and continue it a great while. This aptness of birds above beasts, in imitating the human speech, should be farther examined. Beasts have those parts which are accounted the organs of speech, as lips, teeth, &c. more like to men than birds have: and for the neck, many beasts have it as long as birds. What better gorge or apparatus birds have, may be farther enquired. The birds that are known to speak, are parrots, pies, jays, daws, and ravens:* among which, parrots have a hooked bill, the rest not.

But perhaps this aptness of birds lies not so much in the conformity of the organs of speech, as in their attention: for speech must come by hearing and learning; and birds attend and mark sounds more than beasts; because they are naturally more delighted with them, and practise them more; as appears from their singing.† Those who teach birds to sing, keep them awake, to increase their attention. And cock birds among singing birds are always the better

* The foreign speaking-birds should be also enumerated.

† It is an agreeable surprise to see with what attention a canary bird will take a lesson from the flagelet; and in time be brought to sing an intricate Italian air; provided it be not too long. Though the bird is soon apt to forget it, unless his memory be frequently refreshed by the master.

singers; perhaps, because they are more lively, and listen more.

Assiduity and application in imitating voices, conduces much to imitation: whence there are certain mimicks who will represent the voices of players and others to the life. And there have been those who could counterfeit the distance of voices, so as that when they stand close by; you would think the speech came afar off. How this is done may be farther examined: though I see no great use of it but for imposture.*

SECT. XIX.

THE REFLEXION OF SOUNDS.

THERE are three kinds of reflexion in sounds; viz. 1. concurrent; 2. iterant, or echo; and, 3. super-reflexion, or the echo of an echo.

* Many persons have seen a remarkable instance of this kind in a certain smith of London, who had an extraordinary talent in making his voice appear to come from any part of the room, or house, where he was; so as to work surprising effects upon those who were not let into the secret: and thus, it is said, he once counterfeited a man's voice coming out of a large cask, in a cart loaded with empty casks, as it was going along the street; to the great astonishment and perplexity of the carman.

The reflexion of visible objects, by mirrors, may be commanded; because, passing in right lines, they may be directed to any point: but the reflexion of sounds is hard to direct; because a sound, filling larger spaces in arched lines,* cannot be so guided: whence the ways of making artificial echoes have not been practised.† And no echo, yet known, returns in a very narrow space.

The natural echoes are made by walls, woods, rocks, hills, and banks. As for water being near, it makes a concurrent, but farther off, an iterant echo: for there is no difference between the concurrent echo and the iterant, besides the quickness, or slowness of the return. But water, doubtless, helps the propagation of the echo; as well as of original sounds.

If a person speak in a trunk stopt at the farther end, the blast returns upon the mouth: but

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* As being propagated pulses of the atmosphere, or medium.

† Might not the making of artificial echoes be now practised with success? Surely, the many discoveries every where allowed to be made in the business of sounds, since the invention of the air-pump, and the improvements of Sir Isaac Newton, may enable us to produce more effects than before: otherwise it is a presumption, that these discoveries are either not just, or not very significant; or else, at the modern philosophers are very indolent.

no sound at all: for the closeness which preserves the original, is not able to preserve the reflected sound. Besides, echoes are seldom created but by loud sounds: whence there is less hope of making artificial echoes in air, confined within a narrow concave. Yet it has been tried, that by leaning over a well twenty-five fathoms deep, and speaking, though but softly, the water returned an audible echo. It should also be tried, whether speaking in caves, where there is no issue, except in the mouth, will not yield an echo, as wells do.

Echoes move as original sounds do, in a sphere of air. It were proper to try the production of echoes, where the reflecting body makes an angle: as against the return of a wall, &c. In mirrors, there is the like angle of incidence, from the object to the glass, as from the glass to the eye.* And if a running ball be struck sideway, the re-bound will be as much the contrary way: and whether there be any such reflexion in echoes, may be tried; that is, whether a person will hear better, by standing on the side of the reflecting body, than by standing where the voice is; or any where, in a right-line, between. Trial, likewise, should be made, by standing

* It is an axiom, in optics, that the angle of incidence is equal to the angle of reflexion, on all kinds of surfaces.

nearer the place of reflexion, than the speaker; and again, by standing farther off: to find whether echoes, as well as original sounds, be not strongest near hand.*

In many places may be heard a number of echoes one after another: that is, when there is a variety of hills, or woods, some nearer, some farther off; so that the return from the farther being last created, will be likewise last heard. As the voice goes round the person who speaks, so does the echo: for there are many back-echoes, as well as front ones.

To make an echo report three, four, or five words distinctly, it is requisite that the reflecting body be at a good distance: for if it be near, yet not so near as to make a concurrent echo, it chops with you of a sudden. It is necessary, likewise, that the air be not much confined; for air confined at a great distance, has the same effect as air at large, in a small distance. And therefore, in the trial of speaking in the well, though the well was deep, the voice came back suddenly; and would bear the report but of two words.

With regard to echoes upon echoes, there is a

* The making of these trials would, doubtless, discover some considerable Secrets for the improvement of Phonicks.

a curious instance thereof, about three or four miles from Paris, near a town called Pont-Charenton; upon the river Seine. The room is a chapel, with the walls all standing, both at the sides and at the ends; and two rows of pillars, after the manner of ailes: the roof is open, and no arch-work remaining near any of the walls. There was, against every pillar, a stack of billets, piled above a man's height; which the watermen, that bring wood down the Seine in sacks, laid there for their convenience. Speaking at the one end, it returned the voice thirteen several times; and, I was told, that it would return it sixteen times: for I was there about three of the clock in the afternoon; and it is best, as all echoes are, in the evening. It is manifest, this is not different echoes from several places; but a tossing of the voice, as a ball, different ways: like reflections in looking-glasses; where, if you place one glass before, and another behind, you shall see the glass behind, and the image within the glass before; and again, the glass before, in that; and many such super-reflexions, till the images of the object fail, and die at last: being in every return weaker and more shadowy. So the voice in that chapel, makes succeeding super-reflexions; melting by degrees; and every reflexion growing weaker than the former. Thus, if you speak three words, it will, for three times,

perhaps, report the whole three words; then the two latter words, for a few times; and then the last word alone, a few times; still fading, and growing weaker. And whereas, in echoes of one return, it is extraordinary, to hear four or five words; in this echo of so many returns, you hear above twenty words for three. The like echo upon echo, but only with two reports, has been observed by standing between a house and a hill, and hollowing towards the hill; for the house will give a back-echo; which may be mistaken for the other, though the latter be the weaker.

There are certain letters which an echo can hardly express: as S, for instance; especially when a principal letter in a word. Thus, when I went to hear the echo at Pont-Charenton, there was an old Parisian, who took it to be the work of good spirits; for, said he, call out Satan, and the echo will not deliver back the devil's name; but cries va tén, which, in French, is begone: and thereby I found that an echo would not return S; as being but a hissing, and interior sound.

Some echoes are sudden, and chop again, as soon as the voice is delivered; others are more deliberate, or take more time between the voice and the echo; which is caused by the nearness, or distance: some will report a longer train of words, and some a shorter; some as loud as the

original, or sometimes louder; and others weaker and fainter. Where echoes come from several parts at the same distance, they must make, as it were, a choir of echoes; and so increase the report, and give a continued echo; as we find in some hills that stand in compass like a theatre.*

It does not yet appear, that there is any refraction in sounds, as in vision: for, I do not think, if a sound should pass through different mediums; as air, cloth, wood, &c. it would deliver the sound in a different place from that where it tends: which is the proper effect of refraction.†

* Is not here a foundation for some considerable improvement in the business of sounds; especially with relation to music, and concerts?

† Are not all the common sounds, in a certain sense, refracted? for they all move through a very unequal and mixed medium, the atmosphere, compounded of water, air, salts, and millions of other matters; so that it should seem we have never yet heard any, pure, direct, or unrefracted sound; which, perhaps, requires a pure elastical medium, such as pure and perfect air. And if such a medium of sounds could be procured, what would be the effect of our common instruments played in it? What the effect of such a pure medium condensed to a certain degree? &c. Sir Isaac Newton's doctrine of sounds might, probably, be of some service in this enquiry, were it but more understood, or adapted to the capacities of artificers; who, at present, are rather confounded than instructed by it. The bishop of Ferns and Leighlen, has some useful, and plainer intu-

SECT. XX.

THE RELATION AND DIFFERENCE BETWEEN LIGHT AND SOUND.

BOTH visible and audible species diffuse themselves in a sphere; and fill the whole thereof, to certain limits; being carried to great lengths; but languish, and lessen by degrees, according to the distance of the objects from the sensories. The whole species of both, are in every small portion of the air, or medium; so that they pass through small chinks, without confusion; as appears from levels, to the eye, and from slits, to the ears. Both of them are suddenly and easily generated and propagated; and likewise perish swiftly and suddenly; as upon removal of the light, or touching the sounding body. Both of them receive and carry exquisite and accurate differences; as of colours, figures, motions, distances, in visibles; and of articulate voices, tones, songs, quavers, &c. in audibles. Both of them in their virtue and operation appear to

mations, relating to this subject of refracted sounds; or, as he terms it, cataphonics, or catacoustics. See Philosophical Transactions, Numb. 156.

emit no corporeal substance into their mediums, or the sphere of their activity; nor to cause any evident local motion in their mediums, as they pass; but only to carry certain spiritual forms; the perfect knowledge of the cause whereof is hitherto scarcely attained.* Both of them seem not to generate or produce, any other effect in nature, but such as appertains to their proper objects and senses; and are otherwise barren. But both of them, in their own proper action, have three manifest effects: the first is, that the stronger species drown the lesser; as the sun drowns the light of the stars; and the report of ordnance, the voice. The second, that an object of surcharge, or excess, destroys the sense: as the light of the sun, the eye; and a violent sound, the hearing. The third is, that both of them may be reverberated; as in mirrors, and echoes. Neither of them destroys, or hinders the species of the other, though they meet in the same medium; as light, or colour,

* If this cause be meant of the manner wherein the sensations in vision and hearing are performed, it still remains unknown: though the physical or remote causes of both are thought, at this time, to be very well understood. And these causes are sufficient for the production of great effects: so that it might soon be shewn, by endeavouring to produce such effects, whether we are acquainted with these causes, or not.

does not hinder sound; and vice versa. Both of them affect the sense in living creatures; and yield objects of pleasure and dislike: though these objects also affect, and operate upon inanimate thing; viz. such as have some conformity with the organs of the two senses: thus the visible species operate upon a lens, which is like the pupil of the eye; and the audible upon places of echo, which, in some sort, resemble the cavern and structure of the ear.* Both of them operate variously, according to the disposition of the medium: thus, a trembling medium, as smoke, makes the object appear to tremble; and a rising or falling medium, as the air disturbed by winds, makes the sounds therein to rise or fall. The medium most favourable to both, is air; whereto glass, water, &c. are not comparable. In both of them, where the object is fine and accurate, it greatly conduces to have the sense intent and erect: thus we contract the eye when we would see sharply; and erect the ear when we would hear attentively; which, in beasts, that have moveable ears, is more manifest.† The rays of light, when multiplied and

* This will not appear strange, if it be remembered that action and re-action are equal.

† Do not animals, when they would hear distinctly, turn their ear, in a particular manner, to the place from whence

condensed, generate heat; which is a different action from the action of sight: and the multiplication and condensation of sounds generates an extreme rarefaction of the air; which is a material action, differing from the action of sound; if it be true that birds, in their flight, have been made to fall down by great shouts.*

1 Visible species seem to be emissions of the rays of light from the visible object, almost in the manner of odours,† only that they are more incorporeal; but audible species seem to participate more of local motion, like percussions or impressions made upon the air.‡ So that, as all

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they suspect the sound proceeds? and what precise angle of inclination is this.

* This last particular requires a further examination; for there seem to be, hitherto, no certain instances produced, to shew, that mere sound, without heat, flame, or explosion, does cause a rarefaction of the air. See Sect. II. and consult sir Isaac Newton's Doctrine of sounds, Princip. Lib. II.

† The comparison holds true in lucid, but not in illumined bodies; lucid bodies being seen by means of their own light, but illumined bodies by a borrowed one: whereas odours seem to proceed only from the odoriferous bodies themselves; unless there be any scentless bodies that reflect borrowed odours.

‡ Are not these the same that sir Isaac Newton calls pulses.

bodies appear to operate two ways, viz. either by the communication of their natures, or by the impressions and signatures of their motions; the diffusion of visible species seems to partake more of the former, and audible species of the latter. 2. The species of audibles seem to be more manifestly carried through the air than the species of visibles; as a contrary strong wind, will not hinder the sight, though it does the hearing. 3. One difference betwixt visible and audible species, is, above all others, very remarkable; as that whereon many smaller differences depend; viz. visibles are carried in right lines, and audibles in curves. Whence it is, that visibles do not intermix and confound one another, as sounds do. And hence the solidity of bodies does not much hinder the sight, provided the bodies be clear, and the pores in a right line; as in glass, crystal, diamonds, water, &c. but a thin scarf or handkerchief, though bodies nothing so near solid, hinder vision; whilst such porous bodies do not much hinder the hearing: which solid bodies almost stop, or, at the least, weaken. Hence also, small glasses suffice for the reflection of visibles; but greater spaces are required to the reverberation of audibles. 4. Visible objects are seen farther than sounds are heard; that is, in proportion to their magnitude: for, otherwise, a great sound is heard farther than a small

body can be seen. 5. Visibles generally require some distance between the object and the eye; but in audibles, the nearer the sound is to the sensory, the stronger it proves. But in this there may be a double error; the one, because vision depends upon light; and any thing that touches the pupil of the eye all over, excludes the light. For I had it from a very credible person, who was himself cured of a cataract; that while the silver needle removed the film of the cataract, he never saw any thing more clear, or perfect, than that white needle: no doubt, because the needle was less than the pupil of the eye, and so eclipsed not the light from it.* The other error may be, because the object of sight strikes upon the pupil of the eye directly, without any interception; whereas the cavity of the ear keeps off the sound a little from the organ; so that there is some distance required in both. 5. Visibles are sooner carried to the sense than audibles, as appears in thunder and lightning, the flash and report of a gun, &c. I conceive also, that the species of audibles hang longer in the

* Does sir Isaac Newton's theory of vision, by pressure, reach this case? or, is the fact well confirmed? or is there not still some deficiency in our knowledge of the causes of vision; especially in particular disorders of the eyes? which seem very little understood; as may appear from the empirical practices of oculists.

air than those of visibles: for although even visible species hang some time, as when rings are twirled round, they shew like spheres; and a fire-brand carried swiftly along, leaves a train of light behind it, &c. yet sounds seem to remain much longer, because they are carried up and down with the winds: and because the distance of the time is great, betwixt the flash of a cannon seen, and its report heard, twenty miles off.* 6. There are no objects found so odious and ungrateful to the sense in visibles, as in audibles: for odious sights rather displease, as they excite the memory of odious things, than by the immediate object itself. Whence such sights, in pictures, are not very disagreeable; but in audibles, the filing of a saw is so offensive as to set the teeth on edge: and the ear is presently shocked at harsh discords in music. 6. In visibles, if you come suddenly out of great light into the dark, or out of the dark into a glaring light, the eye is dazzled for a time, and the sight confused: but whether there is any such effect after great sounds, or after a deep silence, should be enquired. 'Tis an old tradition, that those who dwell near the cataracts of the Nile, are deaf: but we find no such effect in engineers, millers, and those that live upon bridges. 7. It seems the impression of colour is so weak, as not to

* See above, Sect. III.

operate but by a cone of direct rays, or right lines; whereof the basis is the object, and the vertical point in the eye, whence there is corradiation, and conjunction of beams: and these beams, so sent forth, are not sufficient to produce the like borrowed, or secondary beams, without reflection; for the beams pass and give little tincture to the air adjacent; otherwise we should see colours out of a right line. But though this happens in colours, it is not so in the body of light: for when there is a skreen between the candle and the eye, yet the light passes the paper, for example, when a person is writing by candle-light; so that the light is seen where the body of the flame is not seen; and where any colour would not be seen, that was placed where the body of the flame is. I judge, that sound is of this latter nature; for when two persons converse, with a wall betwixt them, the voice is not, perhaps, only the original sound which passes in an arch-line: but the sound that passes above the wall, in a right line, may produce the like motion round about it, as the first did; though weaker.*

* This comparison betwixt sight and hearing, might be carried to a much greater length: as it stands here, 'tis little more than a recapitulation of what is before delivered; only with a view to such a comparison. They are compared, in some few respects, by sir Isaac Newton in his

SECT. XXI.

OF THE SYMPATHY, OR ANTIPATHY, OF SOUNDS, WITH ONE ANOTHER.

ALL concords and discords of music, may be aptly called the sympathies and antipathies of sounds; so, in that music termed broken, or consort-music; some consorts of instruments, are sweeter than others: a thing not hitherto sufficiently observed. Thus the Irish harp and the base viol, consort well; so do the recorder and stringed-instruments; organs and the voice, &c. but virginals and the lute, the Welch harp and Irish harp, or the voice and pipes, alone, agree not so well. But for the melioration of music, with regard to exquisite consorts, there is much matter left for trial and enquiry.*

Optics and Principia; and, in some others, by the learned prelate so often mentioned already. But the subject is by no means exhausted; or brought to afford the necessary axioms for practice.

* And perhaps, the Italians themselves, have not advanced music to half that degree of perfection it is capable of receiving from philosophical improvements, to be made by such as have a head as well as a hand.

'Tis a common observation, that if a lute or viol be laid upon its back, with a small straw upon one of the strings; and another lute, or viol, be laid by it; and the unison to the former string be struck in the latter, it will make that string move, as appears, both directly to the eye, and by the effect of making the straw fall off. And the like happens if the diapason, or eighth to that string be struck, either in the same lute, or viol, or in others lying by: but in none of these, is there any report of sound to be discovered, but only motion. It has been advised, that a viol should have a set of wire-strings below, as close to the belly as a lute, and then the gut-strings mounted upon a bridge, as in ordinary viols; so that, by this means, the upper strings being struck, should make the lower resound by sympathy, and thus meliorate the music. If this succeed, sympathy will appear to operate as well by the report of sound as by motion. But this device I conceive of no use; because the upper strings, which are stopped in great variety, cannot maintain a diapason with the lower, which are never stopped; but if it has any advantage, it must be seen in instruments that have no stops; as virginals and harps; wherein trial may be made of two rows of strings, distant the one from the other.

The experiments of sympathy may, perhaps, be transferred from stringed instruments, to others; as, if there were two bells in unison in one steeple, to try whether striking the one would move the other, more than if it were a different cord: and so in pipes, of equal bore and sound, to try whether a light straw, or feather, would move in one pipe, when the other is blown in unison with it.

It seems both to the ear and eye, that the instrument of sense has a similitude, or sympathy, with that which gives reflection: thus the pupil of the eye is like crystal, glass, or water; and the ear, a sinous cavity, with a hard bone, to stop and reverberate the sound, like the places of echo.*

* Hence may be derived a capital rule, not only for the making of new musical instruments, but also many other engines and instruments for helping, improving, and perfecting the senses. The imitation of nature is the shortest and surest method for practice; but then nature ought first to be well understood.

SECT. XXII.

OF THE MEANS OF HINDERING, OR IMPROVING THE HEARING.

WHEN a man yawns, he cannot hear so well: the membrane of the ear being then extended; so as rather to repel the sound, than attract it. We hear better when we hold our breath, than otherwise; whence, in all listening, men hold their breath: for, in all expiration, the motion is outwards; and therefore rather drives away the voice, than draws it in. Besides, in all labour, that requires strength, we hold the breath; and listening after any sound that is heard with difficulty, seems a kind of labour.

Let it be tried, for a help to hearing, to make an instrument like a funnel, the length of six inches or more; the narrow part whereof may fit the hole of the ear, and the broader end swell much larger, like a bell.* Let the narrow end of it be applied close to the ear; and observe whe-

* This is the instrument now in common use for the deaf; and might, doubtless, be considerably improved, from a tolerable knowledge in phonicks.

ther a sound will not be heard distinctly at a greater distance than without this instrument. I have been told, that in Spain they use an instrument, which applied to the ear, helps those that are thick of hearing.

Though the lips be shut close, there is a murmur yielded by the roof of the mouth; as in dumb men: but if the nostrils are likewise stopped, no such murmur can be made, unless in the bottom of the palate towards the throat. Whence it appears, that a sound in the mouth, except such as that just mentioned, passes from the palate through the nostrils, if the mouth be stopped.

SECT. XXIII.

THE SPIRITUAL AND FINE NATURE OF SOUNDS.

THE repercussion of sounds, which we call echo, is a great argument of their spiritual nature; for if it were corporeal, the repercussion should be caused in the same manner, and by the like instruments, as the original sound: but we see what a number of exquisite instruments must concur in speaking: whereas there is

no such things concerned in the returning of words; but only a plain stop and repercussion.*

The requisite differences of articulate sounds carried along in the air, shew that they cannot be signatures, or impressions in the air: for tho' seals make excellent impressions; and though sounds in their first generation, may be conceived as impressed; yet the propagation and continuance of them, without any new sealing, shews them not to be impressed.†

All sounds are suddenly made, and suddenly perish; but neither this, nor the exquisite differences of them, is so wonderful; because the quaverings and warblings in lutes and pipes, are as quick; and the tongue, though but a gross instrument, makes no fewer motions in speech than there are letters in all the words it utters. But that sounds should be so speedily generated, and carried so far every way, in so short a time, is more surprising. For example; if a man speak aloud in the middle of a field, he may be heard a furlong round him; and that in articulate sounds, entire, in every little portion of the

* This is easily cleared up on the supposition of aerial pulses.

† This drives at a higher, more immediate, and spiritual explanation of sounds, than that of the impulse of the air, with which we seem to rest generally satisfied.

air: and all this shall be done in less than a minute.

The sudden generation and destruction of sounds, must proceed from hence; either that the air suffers some force by sound, and then restores itself, as water does; or, that the air readily imbibes the sound as grateful; but cannot maintain it: for the air seems to have a secret appetite of receiving sound at first; but then other gross and more material qualities presently suffocate it; like flame, which is suddenly generated, but instantly extinguished, by the enmity of the air, or other ambient bodies.*

Sounds, in general, are divided into, 1. musical, and immusical. 2. Trebler, and bass. 3, Flat, and sharp. 4. Soft, and loud. 5. External, and internal. 6. Clear, harsh, and purling. And, 7. articulate, and inarticulate.†

* Let Sir Isaac Newton be consulted upon this head. See Princip. Lib. II. Prop. 50.

† This enquiry is not so far finished as those of Winds, Life and Death, &c. whence we find here no canons, or axioms, deduced in form; though there are the seeds of several, sown through the whole. And whoever is disposed to improve the History of Phonicks, which is still greatly deficient, might do well to work upon this plan; range the whole more exactly; add the later instances; and draw out the axioms according to the directions of the Novum Organum, and the other more finished examples of the author, the History of Life and Death, &c. Were a man, with

We have taken some pains in this enquiry about sound; not only because it is a secret and incorporeal quality in nature; but because we were willing, in our first attempt towards a just natural and experimental history, to give an example of a tolerably exact enquiry; intending to do the like in another article, or two:* being desirous that men should thoroughly perceive, what a severe and rigid thing every true enquiry into nature must necessarily be; and hence, accustom themselves to enlarge their minds by the light of particulars, to the ample measure of the universe; and not contract the universe to the narrow measure of their own minds.†

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a tolerable talent at experiments, to proceed upon this design, he might, doubtless, improve the subject of acoustics to a considerable pitch; especially if he became acquainted with the particulars intimated on this head by the Bishop of Ferns and Leighlin; Dr. Grandi; and the experiments of Mr. Derham; all of them to be found in the Philosophical Transactions. To which may be added, for the physical part, Mr. Boyle; and, for the mathematical, Sir Isaac Newton. There are also some useful hints to this purpose, in the Essay of Mr. Whiston and Mr. Ditton, for discovering the Longitude at Sea.

* As that of Imagination, Vegetables, Sympathy, &c.

† If farther directions be wanted for the conduct of enquirers, the reader may find them in the second part of the Novum Organum.

SPIRITS IN BODIES.

ALL solid bodies consist of two different parts; viz. pneumatical and tangible. The pneumatical substance in some bodies, is their native spirit; in others, plain air enters; as in bodies dried by heat, or age: for when the native spirit goes out, and the moisture with it, the air, in time, gets into the pores. And these bodies are always more brittle; because the native spirit is more yielding and flexible than air. The native spirits, also, admit of great diversity; as being either hot, cold, active, dull, &c. whence most of the virtues and qualities of bodies proceed; but the air, intermixed, is without any particular virtues; and makes things more insipid, and unactive.* See the articles *Imagination*, *Nature*, and *Sympathy*.

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* The due prosecution of this enquiry has been already more than once recommended; and is, possibly, of as great consequence as any enquiry in all physics: for if we trace nature closely in her operations, perhaps we shall find, that she uses the mediation of these spirits in all her latent processes of vegetation, animalization, mineralization, and the production of numerous changes in bodies. But we would, by no means, anticipate the enquiry; only endeavour to revive it: for it seems to have languished of late. See Dr. Power's Digression upon Animal Spirits, in his Experimental Philosophy, page 61. See also, Sir Isaac New-

SPONGES.

NEAR the bottom of the Streights are gathered great quantities of sponges, from the sides of rocks; being, as it were, a large kind of tough moss. This is the more remarkable, because there are few vegetable substances that grow deep in the sea; but these are sometimes gathered at the depth of fifteen fathom: and, when thrown on shore, they seem of great bulk; but when squeezed together, may be carried in a very small compass.*

SPRINGS.

It was reported by a sober man, that an artificial spring might be thus made. "Find out a "shelving-ground, where there is a great quick "fall of rain-water; and here bury a stone "trough of a considerable length, three or four "feet deep; with one end upon the high, and "the other upon the low ground. Cover the

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ton's doctrine of Comets, Princip. Lib. III. page 473, &c. and the Queries at the end of his Optics.

* The large quantity of surface in sponge, with regard to its bulk, and the great quantity of water it will readily attract and retain, fit it for some considerable purposes in physics. Thus, in particular, it has been successfully applied for the making of hygrometers. See Mr. Boyle's Statical Hygroscope.

" trough with brakes to a good thickness; and " throw sand upon the top of the brakes; and " now, (says he) after some showers are fallen, " the lower end of the trough will run like a " spring of water." This would be no wonder, while the rain lasted; but, he added, that it would continue long after the rain was over: as if the water multiplied itself upon the air, by the help of the coldness and condensation of the earth, and the association of the first water.* See the article *Transmutation*.

STAMMERING.

THE cause of stammering is, perhaps, the refrigeration of the tongue; whence it becomes less apt to move: for naturals generally stammer. But if stammering persons drink wine moderately, they stammer less; because wine heats: and so it is common to stammer more in the first offer to speak, than in continuance; because the tongue is warmed by the motion. In some also, this defect may proceed from the dryness of the tongue; which likewise makes it less apt to

* There may be reason to question the success of this experiment; but many improbable experiments have succeeded, and many probable ones have failed: so fallible a thing is reasoning a priori. If it could be brought to bear, it might prove of considerable use on many occasions; and afford an intimation of the natural origin of springs.

move: for many stammering persons are choleric; bile inducing a dryness in the tongue.*

SUGAR.

SUGAR has abolished the use of honey: so that we have lost the ancient preparations of honey, when it was more esteemed.† It seems there was formerly tree-honey:‡ and one of the ancients relates, that in Trebisond, there was honey issuing from the box-tree, which made men mad. Again, in ancient time, there was a

* The causes here assigned are, perhaps, rather accidental, or concomitant, than efficient; for stammering may sometimes proceed from a particular conformation of the organs of the voice; and as well from a natural as acquired ineptitude in them to the pronouncing of certain letters. The defect seems plainly catching by imitation, as many have experienced; and may be remedied also, by a contrary practice: and, doubtless, the art of curing stammering might be improved by proper application. It seems a principal rule, that the stammerer accustom, or, as it were, break himself to a habit of pronouncing slowly, and distinctly; more frequently dwelling upon those letters, or combinations of letters, at which he is apt to stammer most.

† The ancients had their confections, honey, honey-balsams, and other preparations with honey; after the same manner as we have our preserves, syrups, elæosaccharums, &c. with sugar.

‡ Honey appears to be a vegetable juice, that is barely collected by the bee.

kind of honey which, either of its own nature, or by art, would grow as hard as sugar; and proved not so luscious as ours.* They had also a wine of honey; which they made by dissolving the honey in a large quantity of water, and straining the liquor: they afterwards boiled it to a half, then poured it into earthen vessels, and soon after put it into vessels of wood; and kept it for many years. They have also, at this day, in Russia, and the northern countries, mead-simple; which, well made, is a wholesome drink, and very clear. They make, likewise, in Wales, a compound mead, with herbs and spices. To compensate what we have lost in honey, it is pity but a sugar-mead were brought into use without any mixture of honey:† for, though it

* May not all honey be converted to sugar, by an easy encheiresis? Do not honey, raisins, &c. candy with age, so as to yield grains of actual sugar? May not all the sweet substance contained in malt, be converted into sugar, and treacle? Perhaps sugar is not peculiar to the sugar-cain; but may be obtained from all the sweet juices of trees, fruits, and grains.

† Angelus Sala shews the method of making a kind of wine with sugar, in his Sacoharologia: but he had not the perfect way, which is extremely simple and easy. This subject, surely, would have been better cultivated, if made wines, as they are called, did not lie under some disrepute: which, in part, proceeds from the unskilful and coarse manner wherein they are generally prepared; and, in part

would not be so abstersive and opening as mead, yet it might be more grateful to the stomach, more lenitive, and proper in sharp diseases: for sugar in beer and ale, has good effects in such cases.* See the articles, *Preservation*, and *Vegetables*.

SWEAT.

When a person bathes in hot water, there comes no sweat on the parts under water; because sweat is a kind of colliquation, made neither by an over-dry, nor an over-moist heat:

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again, from the industry of certain persons, whose interest it is to beget a consumption of foreign wines.

* This is a subject I have, myself, prosecuted with some diligence; and, perhaps, far enough to form an axiom or two upon it, that shall contain the substance of several new arts; or lead to the improvement and perfection of brewing, wine-making, vinegar-making, distilling, &c. The axiom here principally meant is this. A saccharine substance, or real sugar, is the basis of all malt-liquors, wines, vinegars, and inflammable spirits. This axiom is derived from a large, and, possibly, a competent number of particular experiments, instances, and observations; after the inductive method: but they are too many to be here inserted. It may deserve a particular treatise, to shew how all kinds of wines, spirits, and vinegars, are procurable to great advantage from mere sugar and water: A doctrine that deserves to be recommended to the sugar colonies abroad, or certain fabricators at home, See the article *Wine*.

for over-moisture somewhat extinguishes heat, as even hot water will quench fire; and an over-dry heat shuts up the pores. Hence men will sooner sweat when covered, before the sun, or fire, than if they stood naked: and earthen bottles, filled with hot water, provokes sweat in bed, better than hot bricks. Again, hot water causes an evaporation from the skin; so as to spend the matter in those parts under the water, before it collects and issues in sweat. Lastly, sweat comes more plentifully, if the heat be encreased by degrees, than if it be greatest at first, or continued equal: for the pores are better opened by a gentle heat, than a more violent one; and, upon their opening, the sweat issues more abundantly. Physicians, therefore, when they provoke sweat in bed, by bottles filled with a decoction of sudorific herbs, might do well to make two degrees of heat in the bottles; and apply the less heated first, and after half an hour, the hotter.*

Sweat is saline to the taste; because that part of the nourishment which is fresh and sweet, turns into blood and flesh; and the sweat is

* The introduction of bagnios has almost abolished the method of sweating by bottles: however the rule holds good of bagnios also; where the heat is a mixture of a dry heat and a moist one; and encreased by degrees. See the article *Bathing*.

only a part separated and thrown off. Raw blood also has some saltness, more than flesh; because the assimilation into flesh happens not without a small and subtile excretion from the blood.*

Sweat comes more plentifully upon the upper-parts of the body, than the lower; because the upper-parts are more replenished with spirits: and the spirits are what send out the sweat. Besides, those parts are less fleshy: and sweat issues chiefly out of the parts that are dry and thin of flesh; as the forehead and breast.†

Men sweat more in sleep, than waking: yet sleep rather checks, than promotes other evacuations; as rheums, diarrhœas, &c. because in sleep the heat and spirits naturally move inwards, and there continue; but when they are once collected within, the heat becomes more violent, and thence expels the sweat.‡

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* Here is the foundation of a noble enquiry into the business of sanguification, assimilation, and excretion; a subject hitherto not prosecuted suitably to its merits, nor the intimations given for it by the author.

† The miliary glands are, at present, made the principal organ of sweat; which lie dispersed over the whole surface of the body, under the cutis: and if these glands are thicker set in some parts than in others, as the forehead, breast, &c. and sweat be most plentiful in these parts, we have hence a nearer approximation to the cause.

‡ Observe here that kind of interpretation, which appli-

Cold sweats are often mortal, and always suspected; as in great frights, hysteric disorders, &c. for such sweats proceed from a relaxation, or desertion of the spirits; whereby the moisture of the body, which heat kept firm in the parts, separates and flies off.

Sweat is hurtful in those diseases that cannot be discharged by it; and in that case, ought rather to be stopped; as in diseases of the lungs, and fluxes of the belly: but in those diseases that are expelled by sweat, it relieves and proves serviceable; as in agues, pestilential fevers, &c. for here sweat is partly critical, and drives out the offending matter; but in the former cases, it either proceeds from the labour of the spirits, which shews them oppressed: or from motion of consent; when nature, unable to expel the disease where it is seated, moves to a general expulsion over all the body.*

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ed to the human body, is the principal means of improving both physiology, nosology, and the whole science of medicine.

* This subject seems to have been very sparingly touched by physicians; though, certainly, a thing of great consequence in the improvement of their art. It is true, sudorifics are much in use; and sweating is much practised; but a physical knowledge of the nature, cause, and effects of sweat; with the best methods of raising, governing, and directing it, in the cure of certain diseases, appears to be

SWELLING.

It has been observed, that plates of metal, and especially of brass, presently applied to a contusion, will keep down the swelling.* The cause is repercussion, without humectation, or entrance of a body: for the plate has only a virtual cold; which does not search into the hurt, as all plaisters and ointments do. The reason why blows and bruises produce swelling, is, because the spirits resorting to assist the part, draw the humours along with them: for it is not the re-action, or return of the humour into the parts upon the blow, that causes it; since the gout and tooth-ach occasion swelling; where there is no percussion at all.† See the article *Putrefaction.*

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still wanting; though, perhaps, our author has here laid the foundations for supplying it. But, we have frequent occasion to observe, there are few who follow his steps.

* But is the practice safe; especially in large contusions?

† The cause here assigned, seems to regard contusions, and that kind of swellings called by the chirurgeons humoural; besides which, there are several others, viz. œdematous, scrophulous, cancerous, &c. the efficient causes whereof are not perhaps sufficiently known.

SYMPATHY AND ANTIPATHY.

THE agreements and disagreements in nature are the spurs of motions; and the keys of works: whence proceed the union and avoidence of bodies: mixture; separation; the deep and intimate impressions of virtues; the conjunction of active bodies with passive; and, in short, the capital things of nature. But this part of philosophy concerning the sympathy and antipathy of things,* otherwise called natural magic, appears exceedingly corrupted: though, as is generally the case, where care has been wanting, there still

* Let no distaste be suddenly taken at the words sympathy, and antipathy: they mean the same as what we now call the laws of nature; only the name being changed, whilst the thing remains the same. Thus, for instance, the laws of attraction and repulsion, might as significantly be called the laws of sympathy and antipathy. The force of words is very extraordinary; and should, if possible, be reduced to a law: they have, at present, the power of making old things become new, and new things become old. Thus, if the present philosophy were put into ancient language; there is reason to believe it would lose much of its currency. And if any ancient, discarded philosophy were to be neatly dressed up, in new words and phrases, there is reason to believe it would have its admirers: as in effect we find it often has had. This, if duly attended to, might serve to rectify a prevalent error, or gross idol of the mind.

remained hope. Whence the operation of this doctrine upon mankind, has a perfect resemblance with certain narcotic medicines; which the same time they procure sleep, cause pleasing dreams. For first, it has rendered the understanding drowzy, by crying up specific properties, occult virtues, and celestial influences; whence men are no longer awake to the discovery of real causes, but indulge themselves in idle notions, and fall asleep; at which time, hope insinuates numerous figments, like so many dreams. And thus vain men hope to understand nature by her front, and person; or to discover internal properties by external resemblances, and their practice is exactly correspondent to this hopeful procedure: for the precepts of natural magic are such, as if men trusted they could till the ground, and eat their bread, without any sweat of the brow; or become masters of every thing by a few indolent and trifling applications of one body to another; then they have continually in their mouths, and produce as vouchers, on all occasions, magnetism, the attraction betwixt gold and quicksilver, and a few more observations of this kind, to gain themselves a credit in other matters; where there is by no means the same relation. But nature offers all that is excellent, to be purchased by a laborious search of the mind, and operation of

the body. We would, therefore, use our utmost diligence in discovering the laws of nature, and interpreting the alliances and relations of things, without giving into miracles, on the one hand, or prosecuting a narrow grovelling enquiry, on the other.*

All bodies have an appetite of union; and avoid a solution of continuity: and of this appetite there are many degrees; but the most remarkable are three; the first in liquors; the second in hard bodies; and the third in tenacious bodies. In liquors this appetite is weak: as appears by their falling in threads, or round drops;

* This was designed by the author as an Introduction to a particular History of the Sympathy and Antipathy of bodies; after the same manner as the History of Winds, Life and Death, &c. but the history itself was never published. The subject is certainly one of the principal in all physics; and well deserving the prosecution of philosophers. But in an affair so dark, and, indeed, so little fitted to the capacities of the generality, we could earnestly wish for the author's direction. To have seen this noble subject treated in his manner, like the subject of Life and Death, for example, might have shewn the direct way of perfecting the enquiry; or even have nearly executed the full design. But for the following attempt, it is a mere Sylva, or collection of materials, experiments, and observations, that want much trimming, and pruning, to fit them for entering a particular History of Sympathy, and Antipathy.

and their continuance, for a small time, in the form of bubbles and froth. In the second kind, this appetite is strong; as in iron, stone, wood, &c. In the third, it is in a medium, between the other two: for this kind of bodies partly follow the touch of another, and partly stick and continue to themselves; whence they rope and draw into threads; as pitch, glew, bird-lime, &c. But all solid bodies are more or less cleaving: and affect the touch of somewhat tangible, rather than of air. For water, in a small quantity, cleaves to any thing that is solid; so would metal if the weight did not draw it off: for leaf gold, or any metal foliated, will cling. But the bodies noted for being clammy and cleaving, are such as have a more indifferent appetite, at once to follow another body, and yet hold to themselves: whence they are commonly bodies ill mixed; that delight more in a foreign body, than in preserving their own consistence; and not greatly abounding in dryness or moisture.*

* This doctrine is now commonly resolved into attraction; as if when that word can be applied, there were an end of enquiry. But whoever considers the phenomena, will find their efficient causes no nearer being discovered, since the modern use of this term than before. In short, both the terms, sympathy and attraction, seem used by the judicious, only to express the phenomenon; and not to assign the efficient cause.

It is a received opinion, that cantharides applied to any part of the body, come in contact with the bladder; and, if they remain long, exulcerate it.* It is likewise received, that a kind of stone, which they bring out of the West Indies, has a peculiar virtue to dissolve the stone in the bladder; and even if applied but to the wrist, to discharge gravel violently.† It is received, that the soals of the feet have a great consent with the head, and the mouth of the stomach: and we see that going wet-shod, to those who are not used to it, will affect both. Applications of hot powders to the feet, first attenuate, and afterwards dry up the rheum. And hence a physician, to express himself mystically, prescribed for the cure of a rheum; that a man should walk continually upon a camomile bed; meaning, that he should wear camomile in his socks. Again, fresh bleeding pigeons are applied to the soals of the feet to ease the head: and soporiferous medicines, applied to the same, provoke sleep. It seems, that as the feet have a sympathy with the head, so the wrist and hands have with the heart. The affections and passions

* Cantharides, though externally applied, manifestly affect the bladder; or give the strangury; as appears by numerous instances, in the application of blister-plaisters.

† This stone does not at present maintain its character.

of the heart and spirits are remarkably discovered by the pulse: and it is often found, that the juice of stock-July-flowers, garlick, and other things, applied to the wrists, and renewed, have cured inveterate agues.* And I conceive, that washing the palms of the hands with certain liquors, may do good. It seems proper in the hot fit of an ague, to hold in the hands eggs of alabaster, and balls of crystal.†

Make a little cavity in the midst of melted lead, when it begins to set; and lodge quicksilver therein, tied up in a piece of linen; and the quicksilver will fix, so as to endure the hammer. This seems a noble instance of induration, by the consent of one body with another;‡ for it appears less reasonable to ascribe it only to the vapour of the lead. Quere, whether quicksilver may thus be so fixed as to become figurable, like

* A proper collection of this kind of effects, well verified by repeated trials, seems hitherto wanting; in order to lay a firm foundation for a sympathetic philosophy; with regard to medicine.

† See this subject farther prosecuted by Mr. Boyle, in his Discourse of Specific Remedies.

‡ Does the author here mean that the quicksilver fixes by consent, as the lead fixes? or, to speak more intelligibly, though less accurately, that the quicksilver fixes because the lead fixes? If this be the meaning, let it be tried, whether quicksilver will not sometimes fix, by being suspended over melted lead; whilst the lead itself remains fluid.

other metals? For if so, vessels might be made of it, provided they come not near the fire.*

There are many things that operate upon the spirits of man, by secret sympathy and antipathy. That precious stones have virtues in the wearing, has been anciently and generally received; and they are said to produce several effects. So much is true; that gems have fine spirits; as appears by their splendour:† and therefore may operate, by consent, upon the spirits of men, to strengthen and exhilarate them. The best stones for this purpose are the diamond, the emerald, the hyacinth, and the yellow topaz.‡ As for their particular properties, no credit can be given to them. But it is manifest, that light, above all things, rejoices the spirits of men: and, probably, varied light has the same effect, with greater novelty: which may be one cause why precious stones exhilarate. It were, therefore, proper to have tinged lan-

* The common experiment of making a counterfeit gold with quicksilver, and Roman vitriol, if it were not contingent, might prove highly serviceable. And I have seen a yellow metal of this kind, that might have easily imposed upon the vulgar.

† Is this a necessary consequence? But let it be considered, that glass and gems have a power of reflecting light, before it actually touches their surface.

‡ See Mr. Boyle upon the Origin and Virtues of Gems.

thorns, or skreens of glass, coloured green, blue, carnation, crimson, purple, &c. and to use them with candles in the night: so likewise to have round, coloured glasses, that are stained thro'; or to have colours laid between crystals, and handles to hold them by. Prisms, also, are pleasant things. There are looking-glasses, common at Paris, with broad borders of crystal; and large counterfeit gems, of all colours, that are very pleasant to the eye; especially in the night. The pictures of Indian feathers are likewise pleasing: and clear streams recreate the eyes and spirits, especially by moon-shine, or when the sun is over-cast.

There are several sorts of bracelets to comfort the spirits; and of three intentions, viz. refrigerant, corroborant, and aperient. 1. The refrigerant may be of a pearl, or coral: and it has been noted of coral, that if the person who wears it, be indisposed, it will turn pale; which may be true, because a hot distemper makes it lose its colour. I recommend also beads, or little plates, of lapis lazuli; and beads of nitre, either alone, or with some cordial mixture. 2. For corroboration, take such bodies as are astringent, without a manifest coldness; as bead-amber, which is full of astriction; yet unctuous, and somewhat warm. I recommend likewise beads of hartshorn and ivory, which are of the

like nature; also orange beads; and beads of lignum-aloes, first macerated in rose-water, and dryed. 3. For opening, I recommend beads of the roots of carduus-benedictus; the roots of male-piony; orrice; calamus-aromaticus; and of rue.*

The cramp is probably a contraction of the sinews; as appears from its coming either by cold or dryness; as after consumptions, and long agues: for cold and dryness, both contract and corrugate. We see also, that chafing a little above the part in pain, eases the cramp; by warming and dilating the contracted sinews. There are two things in use to prevent the cramp; viz. rings of sea-horse teeth worn upon the fingers; and fillets of green periwinkle, tied about the calf of the leg, the thigh, &c. where the cramp usually comes. This seems the more strange, because neither of them has any relaxing virtue, but rather the contrary: Whence they appear to operate rather upon the spirits in the nerves, than upon the substance of the nerves themselves.†

* There seem not to have been sufficient trials made of these things, in order to form a valid judgment upon them.

† The terms nerves and sinews seem to be here used as convertible: but in the anatomical sense, they are widely different; the sinews being properly not nerves, but the

Light may hence be derived, to shew how things which stop the struggle of the spirits, help in diseases, contrary to the intention: for in curing the cramp, the intention is to relax the sinews; but the contraction of the spirits, that they may struggle less, is the best remedy. So, to procure easy travail, the intention is to bring down the child; but the best help is, to prevent its coming down too fast. So, in pestilential fevers, the intention is to expel the infection, by sweat and exhalation; but the best means to do it is by nitre, and other cool things; which for a time arrest the expulsion, till nature can effect it more quietly. It seems to be an excellent axiom, and of great use, that whatever appeases the struggle of the spirits, promotes their action.*

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tendons of the muscles: and in this sense, an involuntary contraction of the tendons, or rather, perhaps, of the belly of a muscle, may be the cause of the cramp, or the actual cramp itself.

* This intimates a method of interpreting nature, for the perfecting of practice; which philosophers make so little use of, that it should seem they do not know there is any such method practicable to advantage. And when they will be sensible of it, so as to endeavour the improvement of medicine by its means, is uncertain. To talk of forming aphorisms, investigating causes, and raising axioms, is talking in a language almost unknown; and yet, unless these

It has been long received, and confirmed by trial, that the dried root of the male-piony, tied to the neck, helps in the falling-sickness; and likewise in the incubus or night-mare. The cause of both these diseases, and especially the epilepsy, may be the grossness of the vapours from the stomach; which rise and enter the cells of the brain: so that the effect is here performed by the extreme and subtile attenuating virtue of the simple. I judge the like of castor, musk, rue-seed, the seed of agnus-castus, &c.

To wear the blood-stone, is thought good against bleeding at the nose: and may have its effect by astringing and cooling of the spirits. It has been anciently received (for Pericles used it) and is still practised, to wear little bladders of quicksilver, or tablets of arsenick, as preservatives against the plague: not for any assistance they yield the spirits, but because, being poisons, they attract the malignity.*

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things be procured, neither philosophy nor medicine can be considerably improved.

* The wearing of arsenick, in the way of amulet, having had poisonous effects, is now justly laid aside. The practice has been common in times of the plague; and is said to have arisen chiefly from an ignorance of Arabic; the word in the Arabian authors which is rendered arsenick, properly signifying cinnamon.

We see scare-crows are set up to keep birds from corn and fruit; and it is reported, that the head of a wolf, dried and hung up in a dove-house, will frighten away weasles, polecats, &c. and perhaps the head of a dog will do as much; for those vermine with us, know dogs better than wolves.

The brains of some creatures roasted, and taken in wine, are said to strengthen the memory: as the brains of hares, deers, &c. And this seems peculiar to the brains of those creatures that are fearful.*

The ointment of witches, is reported to be made of the fat of children, dug out of their graves; the juices of smallage, wolfsbane, and cinquefoil, mixed with fine wheat-flower. But, I suppose, the soporiferous simples, are fittest for this purpose; such as henbane, hemlock, mandrake, moonshade, tobacco, opium, saffron, &c.

It has been observed, that the diet of women with child affects the infant; so, for the mother to eat quinces, and coriander-seed, in large quantities, which repress vapours that would

* Little credit can be given to these relations, for any thing that has hitherto been approved upon competent experience.

ascend to the brain, makes the child ingenious: and, on the contrary, to eat largely of onions, beans, or such flatulent food; to drink wine, or spirituous liquors immoderately; to fast much; or be given to musing; all which send vapours to the head; endangers the child's becoming lunatic, or of weak memory. And I judge the same of tobacco often taken by the mother.*

The flesh of a hedge-hog dressed and eaten, is said to be a great drier: and indeed the juice of a hedge-hog, should seem to be harsh and dry; because it puts forth so many prickles. For plants that are full of prickles prove generally dry: as briars, thorns, barberries, &c.† and hence the ashes of a hedge-hog are said to be a great desiccative in fistulas.

Mummy has a great virtue to stop bleeding; which may be ascribed, in some measure, to its mixture of balsams that are glutinous; and also to a secret property; because the blood attracts man's flesh. And it is approved that the moss growing upon an unburied skull, stops blood

* These particulars require better confirmation.

† These larger observations which offer at a just interpretation of nature, or attempts for the raising of axioms, cannot be too carefully noted; as well for their own sakes, as the example they hold out, of the end to which all physical enquiries should be directed.

powerfully: so does the powder of blood, separated from the serum, and dried.*

It is reported, that the white of an egg, or blood, mixed with salt-water, collects the saltness; and makes the water sweeter. This may be effected by adhesion; as in clarification. Perhaps also blood, and the white of an egg, have some sympathy with salt: as all life has. We see that salt applied to a cut finger heals it; whence salt appears to attract blood, as well as blood attracts salt.†

It has been anciently received, that the sea-hare hath an antipathy to the lungs, so as if it comes near the body to corrode them. The cause is conceived to be, a quality the hare has of hearing the breath and spirits; as cantharides operate upon the watry parts of the body. And it is a good rule, that whatever operates upon a certain kind of matter, operates most

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* There is something extraordinary intimated here: but we dare not pronounce upon it, for want of a sufficient number of competent experiments.

† Does blood attract salt by any other than its aqueous part? There are other queries to be proposed upon this head; but for our own part, we had rather rise up to make experiments, than sit down to ask questions: and to say the truth, experiments are the only answers of any significance in all these cases; for conjectures, and talk, and reasoning, without them are childish and impertinent things.

upon those parts of the human body, which abound with that kind of matter.*

What is dead, corrupted, or voided, has generally an antipathy with the same thing alive, or sound; and with the discharging parts: thus the carcass of a man is most infectious and odious to a man; the carrion of a horse to a horse, &c. purulent matter, ulcers, carbuncles, scabs, &c. to sound flesh; and the excrement of every species to the creatures that discharges them: but excrements are less pernicious than corruptions. It is a common observation, that dogs know the dog-killer: for when in times of infection, some petty fellow is sent out to kill the dogs; though they have never seen him before, yet they will all come out and bark, and fly at him.†

The relations as to the force of imagination, and the secret instincts of nature, are so uncer-

* I would willingly avoid an over-officiousness in pointing out the more fundamental parts of this piece: but the numerous axioms latent in it, have been so little regarded, and philosophers are usually so little acquainted with the infinite use of canons, large observations, and axioms, that it is in a manner necessary to indicate them as often as they occur.

† This is a pregnant aphorism, and an extensive observation to the present purpose; that from direct phenomena, searches deep into nature.

tain, that they require a deal of examination, before we conclude upon them. I would have it thoroughly examined whether there be any secret passages in sympathy, between persons near in blood: as parents, children, brothers, sisters, husbands, wives, &c. There are many reports in history, that upon the death of persons nearly related, men have an inward feeling of it. I myself remember, that being at Paris, and my father dying in London, I had two or three days before his death, a dream, which I told to several English gentlemen; that my father's house in the country was plaistered all over with black mortar.* There is an opinion abroad, whether idle or no, I cannot say; that affectionate and tender husbands have a sense of their wives' breeding, by some accident in their own body.†

Next to those near in blood, there may be the like passage, and instincts of nature, between great friends and enemies: and sometimes the

* It is certainly difficult for men educated in the common way, to enquire strictly and philosophically into this part of the present subject. The mind seems almost to dread it; as if fearful of discovering more than reason is willing to allow.

† Such particulars as these ought to be diligently enquired after, if we desire to have any tolerable knowledge of the subject in hand; but few philosophers are able to keep their countenance at the mention of them.

notice is given to a second person. Philip de Commines, a grave writer, reports, that the Archbishop of Vienna said, one day after mass, to Lewis the XIth of France: "Sire, your mortal enemy is dead;" at which time, Charles, Duke of Burgundy, was slain in the battle of Granson against the Switz. Trial also should be made, whether compact or agreement has here any effect; as if two friends should agree, that such a day in every week, they being in distant places, should pray for each other; or put on a ring for each others sake; to try whether if one should break his promise, the other would have any feeling of it, in his absence.*

If there be any force in the imaginations and affections of single persons, it is probable much greater in the joint imaginations and affections of multitudes. If a great battle should be won or lost in a remote country, is there not some sense thereof in the people it concerns, because

* These experiments have not, perhaps, been made; at least not by the proper persons; who should, doubtless, be men or women of strong faith, or imagination: but then they should also be persons of great veracity; or join men of more solidity along with them: otherwise we might be easily imposed upon. And to say the truth, experiments of this kind are attended with great difficulty and uncertainty. For the method of facilitating and rendering them more able, see the article *Imagination*.

of the great joy or grief that men are sometimes possessed with at once? Pius Quintus, at the very time that memorable victory was gained by the christians against the Turks, in the sea-fight of Lepanto, being then hearing causes in the consistory, broke off suddenly, and said to those about him, "It is now rather time that we should give thanks to God for the great victory he has granted us against the Turks." It is true, that victory had a sympathy with his spirit, for it was merely his work to conclude the treaty. It may be this revelation was divine: but what shall we say to a number of examples among the Grecians and Romans, where the people being in the theatre, have had news of victories and overthrows some days before any messenger could arrive?* The general root of superstition may indeed hold in these things, viz. that men observe when matters hit, but not when they miscarry, and commit the one to memory, but forget the other.

We have already laid down some rules for making experiments upon the power of imagination, and added some means of fortifying it; together with a few directions and instances of its force upon beasts, birds, plants, and inanimate

* But might not these be state artifices, used to feel the pulse or raise the spirits of the people?

bodies;* constantly requiring that the trials be only made upon subtile and light motions—for you will sooner, by imagination, bind a bird from singing than from eating or flying; and I leave every man to chuse the experiments which himself thinks most commodious. But to add a few examples: observe to use some imaginant, according to the former rules, for binding a bird from singing, or a dog from barking. Try also the imagination of persons whom you shall accommodate with things to fortify it, as in cock-fightings, to make one cock more courageous, and the other more cowardly. Try it also in the flying of hawks, chasing of deer, horse-races, and the like comparative motions: for it is easier by imagination to accelerate or check a motion, than to raise or stop it, as it is easier to make a dog go slower than to make him stand still.

In plants also, let the force of imagination be tried upon the lighter sort of motions; as upon the sudden fading or lively vegetation of herbs, or upon their bending one way or other, or upon their closing and opening, &c. And in things inanimate, try the force of imagination upon stopping the working of beer when the yeast is put to it, or upon the coming of butter or cheese-

* See the article *Imagination.*

curd, after the churning, or the addition of the rennet.

It is every where alledged, as an example of secret properties and influences, that the torpedo if touched with a long stick, stupefies the hand.* And it is one degree of working at a distance, to work by the continuation of a fit medium: thus sound will be conveyed to the ear by striking upon a bow-string, if the horn of the bow be held to the ear.

The writers of natural magic attribute much to the virtues remaining in the parts of animals, if taken from them alive, as if the creature in that case infused some immaterial virtue or vigour into the separated part. So much may be true, that any part taken from a creature newly killed may be of greater force than if taken from the like creature dying of itself, as being fuller of spirit.

Trial should be made in the like parts of individuals, as by cutting off part of the stock of a tree, and laying it to putrefy, to see whether this will decay the rest of the stock; or cutting off

* Does the stupefaction caused by the touch of the torpedo proceed from any thing more than a particular motion, whereby the creature lets itself off, as it were, upon being touched? See a curious paper upon this subject in the French Memoirs.

part of the tail or leg of a dog or cat, and laying it to putrefy, to see whether this will keep the other part from healing.

It is supposed a help to the continuance of love to wear a ring or bracelet of the person beloved; but this may proceed from exciting the imagination, which perhaps a glove, or other the like favour, might do as well.

The sympathy of individuals, that have been entire, or in contact, is of all others the most incredible. To take away warts, by rubbing them with somewhat that is afterwards put to consume, is a common experiment. I had from my childhood a wart upon one finger; afterwards, when I was about sixteen, being then at Paris, there grew upon both my hands a number of warts, at least a hundred, in a month's time. The English ambassador's lady (who was far from superstitious), told me she would get away my warts: and in order to it, she rubbed them all over with the fat side of a piece of bacon with the rind on, and among the rest, the wart I had from my childhood; then nailed the bacon, with the fat towards the sun, upon a post of her chamber-window, which was to the south, and in five weeks time the warts went away, and the wart I had so long endured, for company. At the rest I did not much wonder, because as they came in a short time, they might go away so too;

but the vanishing of that which had remained so long, sticks with me. They say the like is done by rubbing warts with a green elder stick, and bury the stick. The experiment might be tried on corns, wens, and other excrescences. I would have it also tried on some parts of living creatures that approach nearest to excrescences, as the combs and spurs of cocks, the horns of beasts, &c. And let it be tried, both by rubbing those parts with bacon or elder, and by cutting off some piece of them, and burying it, to see whether this will have any effect towards consuming the part once joined with it.*

It is constantly avouched, that to anoint the weapon which gives the wound, will heal the wound itself. In this experiment, which I have upon the relation of credible persons, tho' I am not fully inclined to believe it, it is observed, 1. that the ointment employed consists of several ingredients, whereof the strangest and hardest to procure are the moss growing upon the skull of a dead man unburied, and the fat of a boar and a bear killed in the act of generation. The two last I could easily suspect prescribed as a loophool, that if the experiment did not succeed, it

* There are many experiments of this kind related, but no proper collection of them made with the requisite care for forming a just rule or solid judgment upon them.

might be pretended the beasts were not killed at the right time; but for the moss, there is a great quantity of it in Ireland, upon slain bodies, laid on heaps, unburied. The other ingredients are, blood-stone in powder, and some things which seem to have a virtue to stanch blood, as the moss also has. The description of the whole ointment is found in Crollius's chemical dispensatory. 2. The same kind of ointment applied to the wound itself has not the effect, but only when applied to the weapon. 3. They do not observe to prepare the ointment under any certain constellation, so have not the excuse made for the failure of magical medicines. 4. It may be applied to the weapon, though the person hurt be at a great distance from it. 5. It seems the imagination of the person to be cured is not necessary, for it may be done without the knowledge of the wounded; and it has been tried, that if the ointment be wiped off the weapon without the knowledge of the patient, he is presently in violent pain, till the weapon be reanointed. 6. It is affirmed, if the weapon cannot be procured, and an instrument of iron or wood, resembling the weapon, be put into the wound, so as to make it bleed, the anointing of that instrument will have the effect. This I suspect is a device to keep so strange a form of cure in request and use, because many times one can-

not procure the weapon itself. 7. The wound must be first washed clean with white-white, or the person's own urine, and then bound up close with fine linen, and no more dressing is required. 8. The weapon itself must be wrapped up close, as far as the ointment goes, that it takes no wind. 9. The ointment, if wiped off from the weapon, and kept, will serve again, and rather increase in virtue than diminish. 10. It cures in far shorter time than vulnerary ointments commonly do. 11. It cures a beast as well as a man, which subjects the matter to an easy trial.*

The delight we take in popularity, fame, honour, the subduing and subjecting other men's minds, wills, or affections, seems in itself, without regard to consequences, grateful and agreeable to the nature of man. This surely is not without some signification, but seems as if the spirits and souls of all men came out of one divine limbus, else why should we be so much affected with what others think or say? The best temper of mind desires a good name and true honour; the lighter sort, popularity and applause; the more depraved, subjection and tyranny, as we see in great conquerors and disturbers of the

* Those who desire farther information upon this extraordinary head, may consult Sir Kenelm Digby and Mr. Boyle.

world; and yet more in arch-heretics, for the introducing of new doctrines is an affectation of tyranny over the understandings and opinions of men.*

TEETH.

THE teeth are more affected by cold, in drinking cold liquors, or the like, than other parts, because resistance of bone to cold is greater than that of flesh; for flesh shrinks, but bone resists,

* Though the materials here collected are no way sufficient to build up a sympathetical philosophy, yet they may perhaps afford many intimations and directions for one. Certainly there are in nature great numbers of phenomena and effects not to be accounted for upon mechanical principles, or the vulgar doctrine of matter and motion, but require sublimer solutions: whence proceeds the influence and ascendency which one man's mind has over another; whence the attractions, repulsions, and more secret relations in bodies, of which the instances are numerous, particularly in the doctrine of menstruums. If proper collections were made of the more capital instances of this kind, if the common sympathetic experiments were repeated with care and judgment, and their number enlarged; if the common traditions upon this subject were sifted and purged; and lastly, if a set of judicious and experienced philosophers were for some time employed in this way, we should then see whether a harvest of serviceable canons and axioms might not be reaped, for extending, improving, and perfecting the common physics; which, for want thereof, appears but a lifeless thing.

whereby the cold becomes sharper. Again, the teeth are without blood; but blood helps to qualify cold, whence the sinews are much affected with cold, as being parts without blood. So the bones, in sharp cold, grow brittle, and therefore all contusions of the bones are harder to cure in frosty weather.* See the article *Bones.*

TIME.

TIME changes fruits from sour to sweet, but potable liquors from sweet to sour: the cause is, the collection of the spirits together, for in both kinds the spirit is attenuated by time; but in the first it is more diffused and subdued by the grosser parts, which the spirits only digest; whilst in drinks the spirits reign, and finding less opposition of the parts, become themselves more strong, and thus strengthen the liquor; so that if the spirits be of the hottest sort, the liquor becomes apt to burn; but in time, when the higher spirits are evaporated, it causes likewise more sourness.†

* Sensation is usually denied to bone, any farther than the nerves are affected by its means.

† The due settling of this point depends upon a knowledge of fermentation and acetification. See Boerhaave's Chemistry and Stahl's Zymotechnia.

TITILLATION.

Tickling is most felt in the soles of the feet, under the arm-pits, and on the sides; from the thinness of the skin, joined with the seldomness of being touched in those parts: for all tickling is a light motion of the spirits, promoted by the thinness of the skin, and the suddenness and unfrequency of touch: so a feather tickles by being drawn along the lip, or cheek; but not a thing more obtuse, or a stronger touch. As to suddenness; we find no man can tickle himself: and the palm of the hand, though it has as thin a skin as the parts above-mentioned, yet is not ticklish; because accustomed to be touched. Tickling also causes laughter; perhaps from the emission of the spirits, and so of the breath; for, upon tickling, there is always a starting, or shrinking away of the part, to avoid it: and if the nostrils be tickled with a feather, or straw, it procures sneezing; which is a sudden emission of the spirits, that, likewise, expel the moisture. And tickling is always painful, and not well to be endured.* See the article *Venery*.

TOBACCO.

Tobacco is a thing of great profit, if it be in request; though the charge of making the ground,

* This article belongs to a sublimer anatomy than the common.

and otherwise, is considerable: but the English tobacco has little reputation; as being too dull and earthy. So that, to render tobacco more aromatic, and better concocted, here in England, might be a very beneficial thing. Some have attempted it by drenching English tobacco in a decoction of the Indian: but such methods are sophistications and toys; for nothing that is once perfect, and has run its course, can receive much amendment. We must ever resort to the beginning of things for melioration.* The way of ripening tobacco must, as in other plants, proceed from the heat, either of the earth, or the sun. We see something of this kind practised in musk-melons, which are sown in a hot bed, exposed to the south-sun, and laid upon tiles, to increase the heat by reflection; and covered with straw, to defend them from the cold. They also remove them; which adds some life: and by such helps the melons become as good in England as in Italy, or Provence. These, and the like means, may be tried in tobacco. Enquire also of steeping the roots in a liquor that may give them vigour to put forth strongly.†

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* These are two axioms of great importance; and, if well explained, might afford much light in the conducting of works; and the introducing of meliorations.

† There seems to be no great occasion, at present, for

TONGUE.

The tongue more easily receives impressions, and affords more tokens of diseases, than other parts; as of heats within, which appear most in the blackness of the tongue. And pied cattle are spotted in their tongues, from the tenderness of the part; which thence receives all alterations more easily, than other parts of the flesh.*

TRANSMUTATION.

The eye of the understanding is like the eye of the sense: for as large objects are visible through small chinks; so are great axioms of nature through small and ordinary instances.† The quick depredation which air makes upon watery moisture, and its converting the same into air,‡ appears in nothing more plain than in the sudden dissipation of the little cloud, made by

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cultivating tobacco in England; otherwise the method, perhaps, is no secret; being successfully practised in the south parts of France.

* Some indications are taken from the tongue in distempers; but the interpretations of its signs are not well settled.

† A due collection of which instances, is the readiest and surest way of forming such axioms.

‡ Whether this be an instance of the actual conversion of water into air, may be questioned. How does the experiment succeed in Vacuo?

breathing upon a glass, a sword-blade, or any such polished body that does not detain, or imbibe the moisture; which here scatters and breaks up suddenly: whereas, the like cloud remains long, if it were oily or fat; not because it sticks faster, but because it is air that preys upon water; and flame and fire, upon oil:* whence, to take out a spot of grease, we use a coal upon brown paper; for fire operates upon grease, as air does upon water: and we see oiled paper, or oiled wood, will long remain moist; but grow dry, or putrefy sooner, when wet with water: for air has little effect upon the moisture of oil.†

The same trifling instance of the little cloud upon glass, gems, &c. admirably shews how much the force of union, even in the least quantities, and weakest bodies, conduces to preserve the present, and resist a new form. For this little cloud constantly breaks up first in the skirts, and last in the middle. We see likewise, that

* Is water the pabulum of air; as oil is of fire?

† More than one great axiom of nature is here intimated, that cannot perhaps be justly formed, without a farther improvement of chemistry; particularly that part thereof which relates to the common elements; or grand instruments of the art. See Boerhaave's Chemistry; but particularly, the chapters of fire, air, water, earth, and menstruums; which are considerably improved in his own edition.

much water draws out the juice of a body infused therein; whilst little water is imbibed by the body: and this is a principal cause, why, in operations upon bodies for their alteration, trials, in large quantities, do not answer to the trials in small; and so impose upon many: for the greater the body, the more it resists any alteration of form; and requires much more efficacy in the active body, that should subdue it.*

Anoint pigeons, or other birds, when in their down; or very young whelps, &c. first cutting their hair as short as possible, with some innocent ointment that will harden, and stick very close; to try whether it will not alter the colour of the feathers, or hair. Pulling the first feathers of birds clean off, is said to make the new come white: and, it is certain, white is a penurious colour, that rises where moisture is deficient.† So blue violets, and other flowers, if starved, turn pale and white: birds, and horses, by age, or scars, turn white: and the hoary hair of men, proceeds from the same cause. It is

* Here again are the rudiments of an axiom; containing great light of information, in the conducting of works, and the business of transmutation.

† This is a large, or very extensive observation; as may appear by the subsequent instances, from which it seems to have been drawn.

therefore, probable, that the first feathers of birds will often prove of different colours, according to the nature of the bird; whilst the skin is more porous: but that when the skin is more close, the feathers will come white. This experiment may serve, not only to produce birds and beasts of strange colours; but also to disclose the nature of colours; and shew which of them require a finer, and which a coarser strainer.* See the articles *Colours* and *Percolation*.

In transmutations, or grand alterations of bodies, there always comes a medium between the matter as it is at first, and the resulting matter;

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* We have here an instance of an attempt to raise a work upon the cause derived, or endeavoured to be derived, under the article percolation, Sect. 7. If this cause were verified, or found to be certainly true; it would become an axiom: and the work here intimated would then certainly prove successful, for the end purposed. How far it may succeed, has not perhaps been properly tried. At least, we may hence learn the scope and nature of this whole piece of the Sylva Syvarum; which is to discover causes, and form them into pregnant axioms, that readily direct to works. And certainly, whoever shall understand, and properly practise this method, may produce, not only strange, but highly useful and serviceable effects. The great inconvenience is, that persons well versed in this way, might, in ignorant ages, or ignorant countries, be taken for magicians: of which gross and fatal mistake there are but too many instances.

which medium, is a body imperfectly mixed, and not durable; but transitory; as mist, smoke, vapour, chyle, and the rudiments of animals: and the middle action, which produces such imperfect bodies, is, by some of the ancients, aptly called inquination, or inconcoction; being a kind of putrefaction: for the parts are in confusion, till they settle one way or other.*

It is reported, that sailors having, every night, hung fleeces of wool on the sides of their ships at sea, could squeeze fresh water out of them, in the morning. And, we have tried, that a quantity of wool, tied loose together, being let down into a deep well, about three fathom from the water, for a night, in the winter, increased in weight about a fifth part.†

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* We have here a large observation of very general extent, the capital instances whereof deserve to be collected, in order to raise it into an axiom, or rule of practice. For, thus to operate by transmutation, it should seem that the subject ought to be softened, rarified, or subtilized; that being a form the most susceptible of change. The doctrine of the adepts may deserve to be considered upon this occasion.

† Instances of this kind can only be considered as instances of approach, with regard to the present subject of transmutation; being, perhaps, no more at bottom than methods of collecting the invisible aqueous particles that in the air, (especially near water) and rendering them

It is reported, that in Lydia, near Pergamus, certain workmen, in the time of war, taking refuge in caves, which being stopped by the enemy, the men were starved; but, that the dead bones were, long after, found, and some vessels which they had carried with them; the vessels being now full of water, that was thicker, and nearer approaching to ice than common water: which is a remarkable instance of condensation by long burial;* and of transmutation, as it should seem, of air into water; provided any of the vessels were at first empty. Try, therefore, small bladders of air, immersed in snow, in nitre, and in quicksilver: and if you find the bladder shrunk, the air will appear condensed by the cold of those bodies; as it would be in a cave.†

It is credibly reported, that in the East Indies, if a tub of water be set open in a room where cloves are kept, it will be drawn dry in twenty-four hours; though it stand at some distance

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sensible: which is far from a transmutation. See the articles *Alterations, Concoctum, Gold,* and *Putrefaction.*

* See the article *Burials.*

† Neither the utmost force of cold, nor of the condensor, seem to have been tried for this purpose. See the Chapter of Fire in Boerhaave's Chemistry; where a method is shewn of procuring an extreme degree of artificial cold, by means of ice and spirit of nitre.

from the cloves. And often, when wool is new shorn, our country people fraudulently set some pails of water in the same room, to increase the weight of the wool. But, perhaps, the heat remaining in the wool from the body of the sheep, or gathered by the close lying, helps to draw the watry vapour.

It is also credibly reported, that wool new shorn, being casually laid upon a vessel of verjuice, had, after some time, drunk up great part of the liquor; though the vessel were without flaw, and remained close. So that there was a percolation of the verjuice through the wood, in a kind of vapour.

What facilitates the conversion of air into water, when the air is not gross, but subtilly mixed with tangible bodies; is, that tangible bodies have an antipathy to air: and if they find any liquid more dense near them, they will attract it, condense it more, and, in effect, incorporate it. Thus a spunge, wool, or sugar, being in part put into water, or wine, attract the liquor higher than the surface reaches. So wood, lute-strings, &c. will swell in moist seasons; as appears by the breaking of the strings, the hard turning of the pegs, &c. which is a kind of infusion much like infusion in water; that makes wood swell: as in closing the cracks of bowls, by laying them in water.

There appears also to be a conversion of air into water, in the sweating of marble and wainscot, in moist weather. Which proceeds either from some moisture the body yields; or because the moist air is condensed against the hard body. But it seems plainly the latter; for wood painted with oil-colours, will sooner gather drops in a moist night, than wood alone; because of the smoothness and closeness, which admits no part of the vapour; and therefore turns back, and condenses it into dew: as breathing upon a glass, or other polished body, makes a dew. So likewise, in frosty mornings, we find drops of dew on the inside of glass-windows: and the frost itself upon the ground, is but a condensation of the moist vapours of the night. Dew also, and rains, are only the returns of moist vapours condensed: the dew being condensed by the cold from the sun's departure; and rains, by the cold of the middle region of the air.

It is probable, that what will turn water into ice, may likewise turn air, in some degree, to water. Therefore try the common experiment of turning water into ice, by art;* using air instead

* Viz. Snow, or beaten ice, and salt, or other artificial mixtures: among the strongest whereof is reckoned sal ammoniac dissolved in water; or, what is much stronger, spirit of salt, or spirit of nitre, poured upon ice or snow.

of water. And though it be a greater alteration to turn air into water, than water into ice; yet there are hopes, that by continuing the air longer, the effect will follow: for the artificial conversion of water into ice, is the work but of a short time; whereas this may be tried for a month, or more.

There seem to be these probable ways of converting vapour, or air, into water and moisture. The first is by cold; which manifestly condenses, as we see by the contraction of the air in the weather-glass: whence air by condensation appears to come a degree nearer to water. We see it also in the origin of springs; which the ancients thought owing to the conversion of air into water, promoted by the coldness of the rocks; where springs are chiefly generated. We see it also in the effects of the cold of the middle region of the air; which produces dews and rains. And the experiment of turning water into ice, by means of snow and salt, should be tried, as we before observed, for turning air into water. The second way, is by compression; as in stills, where the vapour is turned back upon itself, by the sides of the still: and again, in the dew visible upon marble and wainscot, towards damp weather. But this is likely to have no great effect, except upon vapour and gross air, already approaching near to water. The third is, by mix-

ing moist vapours with air, and trying if they will not produce a greater return of water; for if so, that increase is a conversion of the air. Therefore put a certain weight of water into a close still, and hang a large spunge above the water, to try what quantity of water may, after heating, be squeezed out of it, in proportion to the water spent; for, if any conversion can be wrought, it will be easiest effected in the small pores of bodies; which is the reason we prescribe a spunge. The fourth way is, by receiving the air into the small pores of bodies; every thing in small quantity being, as we have before observed, more disposed for conversion; and all tangible bodies endeavouring to condense air: but in entire bodies this operation is checked; because, if the air should condense, there is nothing to succeed. It must therefore be tried in loose bodies, as sand and powder; which, if they lie close, do of themselves gather moisture. *

* The several experiments here proposed, may seem not to reach the point; which indeed is a capital work, if understood of an actual artificial change of proper elastic air into the gross body of water. To understand the author's meaning, in this particular, see the article air; and for farther light and direction in the affair, consult the articles *Alteration, Gold, Putrefaction*, &c. There are also some useful particulars relating to this purpose, in the author's History of Winds; Sir Isaac Newton's Queries, at the end

A FIRST DRAUGHT OR THE PARTICULAR HISTORY OF VEGETABLES AND VEGETATION.

Vegetables should be diligently enquired into, as being a principal part of the third day's work; the first producat; and of excellent and general use for food, medicine, and many mechanic arts.*

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of his optics; Mr. Hales's Vegetable Statics; and Dr. Boerhaave's Chemistry, under the chapters of Air and Water.

* The author has here bestowed considerable pains; and collected together a great number of materials for the physical history of vegetation. But what he delivers upon the subject is not, perhaps, so valuable in itself, as for the light and direction it affords in executing the design; by discovering causes, and raising axioms. With this view he recommends several experiments to be tried, that are directly levelled at the investigation of causes: which particular being usually unobserved by the common writers upon agriculture and horticulture; they have often excepted to these experiments, either as unsuccessful, or of little use; without penetrating into the design of the author, who chiefly writes for such philosophers as can learn as much from an unsuccessful experiment, as from one that shall succeed; and understand how to separate and concoct experience into aphorisms, axioms, and sure rules of future practice: [illegible] which light the untried experiments here recommended, [illegible] widely from those commonly practised by gardeners; [illegible]ng a much nobler view. And certainly they are [illegible]inted with the nature and use of the Sylva Sylva-

HEADS OF ENQUIRY.

ARTICLE I. Of the acceleration of germination.

II. Of the retardation of germination.

III. Of the melioration of trees, plants, and fruits.

IV. Of compound fruits and flowers.

V. Of the sympathy and antipathy of plants.

VI. Of rendering fruits and herbs medicinal.

VII. Of curiosities in vegetation.

VIII. Of the degeneration of plants, and their transmutation into one another.

IX. Of the tallness, lowness, and artificial dwarfing of trees.

X. Of the rudiments and excrescences of plants.

XI. Of the production of perfect plants without seed.

XII. Of exotic plants.

XIII. Of the seasons of plants.

XIV. Of the duration of herbs and trees.

XV. Of the different figures of plants.

XVI. Of the principal differences in plants.

XVII. Of composts and helps for ground.

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rum, who do not perceive the excellence of the untried experiments therein recommended, above those that have been usually tried.

XVIII. Of the relation between plants and inanimate bodies.

XIX. Of the relation between plants and animals.

XX. Miscellaneous experiments and observations upon the subject.

SECT. I.

OF THE ACCELERATION OF GERMINATION.

We sowed, in a hot-bed, turnip-seed, radish-seed, wheat, cucumber-seed, and pease. The bed was made of well-rotted horse-dung, laid upon a bank half a foot high, and supported round with planks; and, upon the top, we threw sifted earth, two fingers deep. The seed sown upon it, was first steeped, all night, in water mixed with cow-dung. The turnip-seed and wheat, came up half an inch above ground in two days, without any watering; and the rest came up the third day. The experiment was made in October: perhaps, in the spring, the acceleration might have been greater. Without this help, the seeds would have been four times as long in coming up. But there does not, at present, occur any profitable use of this experiment, unless for sowing of pease; the price whereof is much in-

creased by coming early. It may be tried also with cherries, strawberries, and other fruits which are dearest when early.*

We steeped wheat in water mixed with cow-dung, in water mixed with horse-dung, in water mixed with pigeon's-dung, in human urine, in water mixed with powdered chalk, in water mixed with soot, in water mixed with ashes, in water mixed with bay-salt, in claret-wine, in malmsey, and in spirit of wine. The proportion of the mixture was a fourth part of the ingredient to the water; only of the salt there was not above an eighth part. The urine, the wines, and the spirit of wine, were without any mixture of water. The time of the steeping was twelve hours; the time of the year, October. Along with these was also sown another parcel of unsteeped wheat; but watered twice a-day with warm water: and some we sowed simple, to compare with the rest. The event was, that the grain steeped in the mixtures of dung, urine, soot, chalk, ashes, and salt, came up within six days: and those

* The common hot-beds seem to require some considerable improvements; to make them produce strong and perfect, as well as quick and early. In order to improve them, enquire what is the most immediate or material principle of vegetation: or, if more principles than one are concerned, let them all be duly regarded in the preparation of artificial composts.

that, afterwards proved the tallest, thickest, and strongest, were, first, the urine; then the dungs; next the chalk; next the soot; next the ashes; next the salt; next the wheat, unsteeped and unwatered; next that watered twice a-day with warm water; and next the claret-wine. So that the three last being slower than the ordinary wheat of itself, this culture proved rather prejudicial. As for those that were steeped in malmsey, and spirit of wine; they came not up at all. This is a profitable experiment, for most of the steepings are cheap things: and the goodness of the crop is a considerable point of gain; if the goodness thereof answer the earliness of coming up, as probably it will, both proceeding from the vigour of the seed. The experiment should be tried in other grain, seeds, and kernels; for, perhaps, certain steepings agree best with certain seeds. It should also be tried with roots, steeped for a long time: and in several seasons of the year; especially the spring.†

Strawberries being watered once in three days,

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* See M. Homberg's experiments upon vegetation, in the French Memoirs,

† The farmers, in some counties of England, now commonly steep their seed-wheat in common brine, or the brine of their pork-vats, to advantage. But proper trials of other useful steepings are still wanting; and should be directed from some knowledge of the material cause of vegetation.

with water wherein the dung of sheep, or pigeons, has been infused, will come up early. And perhaps the same might hold in other berries, herbs, flowers, grains, or trees. The experiment therefore, though common in strawberries, is not yet brought into general use. It is a frequent practice to help the ground with dung or manure; but to water it with muck-water,* which seems more powerful, is not practised. Dung, chalk, or blood, seasonably applied, in substance, to the roots of trees, hastens their growth; but without some mixture of water, or earth, perhaps such helps are too hot for herbs.†

The preceding means of promoting germination, depend upon the goodness and strength of the nourishment; or the supporting and exciting the spirits in the plant, the better to attract it: of the latter kind, are the experiments following

1. To plant trees against a wall to the south, or south-east sun, hastens their growth and ripening. The south-east is found better than the

* That is by suffering the dung to steep in the water, whereby a tincture of its more soluble parts will be gained; and the more gross matter fall to the bottom. Perhaps such a tincture may be too rich for certain vegetables, or certain beds; unless made dilute, or used but seldom.

† When used in too great plenty they prove prejudicial; otherwise they greatly invigorate trees that are old or decayed.

south-west for this purpose, though the south-west be hotter; because the heat of the morning succeeds the cold of the night; and partly, because the south-west sun is often too parching. 2. So likewise the planting of them against a chimney, where a fire is kept, hastens their coming up, and ripening: and drawing the boughs into a room where there is a constant fire, produces the same effect; as has been tried in grapes; which will, thus, come a month earlier than otherwise.* 3. Another means of accelerating germination, is by making way for a ready supply, and attraction of the nourishment; whence, gentle digging aud loosening of the earth about the roots of trees; and the removing of herbs and flowers into new earth, once in two years, (for the new earth is always looser) greatly promotes the thriving, and early coming of plants. 4. But the best acceleration, in the way of facilitating the conveyance of the nourishment, is that by means of water.

A standard of a damask-rose, with the root on, being set upright in an earthen pan, full of fair water, half a foot deep in the water; the top rising more than two foot above the surface: and the pan placed in a chamber where no fire was

* And yet prove excellent; as I have seen; particularly in Holland.

kept; within ten days put forth a fair green leaf; and some other little buds, which made a stand for above seven days, without any appearance of decay or withering. Afterwards the leaf faded, but the young buds sprouted on, and opened into fair leaves, in three months time; and continued so a while after, till upon removal we ceased the trial. But the leaves were somewhat paler, and lighter coloured, than others of the same kind. The first buds appeared at the end of October; and, it is probable, if it had been spring-time, the standard would have shot with greater strength, and have grown on, to bear flowers. By this means roses might be set in the midst of a pond; being supported by some prop: which is matter of pleasure, though of small use. The experiment is the more strange, because a like rose-standard being, at the same time, put into water mixed with a fourth part of horse-dung, yielded no leaves; though several buds at the first, as the other did.*

A Dutch flower, with a bulbous root, being, at the same time, placed wholly under water, two or three inches deep, sprouted in seven days; and continued growing long after. A beet-root, a

* No conclusion can be safely drawn from this experiment, for want of knowing whether there were no difference in the roots of the two standards, or other circumstance.

borrage-root, and a radish-root, all their leaves being cut almost close, were treated in the same manner; and had fair leaves within six weeks: and so continued till the end of November.*

If roots, pease, or flowers, may be accelerated in their growth and ripening, a double profit will attend it; because of the advanced price they bear when they come early; and again, because of the quickness of their return: thus, in some grounds which are strong, radishes, for instance, will come in a month; that, in other grounds, would not come in two: and so make double returns.

Wheat being put into water, sprung not at all; whence, probably, there is required some strength and bulk in the body put into water, as in roots: for grain, or seeds, will mortify by the cold of the water. But a little lying casually under the pan, and being somewhat moistened by the exudation thereof, though it appeared mouldy, it was, in six weeks, sprouted half a finger.

It should seem, by these instances, that in point of nourishment, water is a capital thing; and, that the earth does but keep the plant upright; and preserve it from too much heat or

* For the reason why water alone may nourish plants, see Dr. Woodward's Experiments upon vegetation, in the Philosophical Transactions, Numb. 203.

cold:* which is comfortable doctrine for great drinkers. It proves also, that drinks incorporated with flesh, or roots, will nourish more easily than meat and drink, taken separate.†

5. The housing of plants may contribute both to the acceleration and production of flowers and plants, in the colder seasons: and as we house the exotics of hot countries; viz. lemons, oranges, and myrtles, to preserve them; so we may house our natives, to forward them, and make them thrive in the cold seasons. And thus we may have violets, strawberries, and pease all winter; provided they be sown, or removed, at proper times.‡ This experiment is referable to the cherishing of the spirit of the plant by warmth, as well as housing their shoots, &c. So that the means of accelerating germination, are, in particular, eight; and, in general three.

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* A farther scrutiny, and more particular experiments, seem requisite, before any axiom can be formed upon this head. See the chapter of Water in Boerhaave's Chemistry.

† See the article *Foods*.

‡ Due regard must be had, that the hot and dry air of the green-house does not exhale their aqueous parts too fast; and that a proper supply of air and water be given them.

SECT. II.

THE RETARDATION OF GERMINATION.

To make roses, or other flowers, come late, is an experiment of pleasure. The ancients highly esteemed the rosa sera: and indeed the November rose is the sweetest; as having been less exhaled by the sun. The means are these; viz. 1. To cut off their tops, immediately after they have done bearing; whence they will come again the same year about November. They will not come just on the cut tops; but upon those shoots, which were a kind of water boughs: because the sap, that would otherwise have fed the top, will now divert to the side-shoots; and make them bear, though later. 2. To pluck off the buds when newly knotted; for then the side-branches will bear: cutting off the tops, and plucking off the buds, having the same effect, as to retention of the sap for a time; and the diverting it to the roots, that were not so forward. 3. To cut off some few of the top boughs in the spring, and suffering the lower to continue growing on: for the shoots help to draw up the sap more strongly; as in the polling of trees, it is usual to leave a bough or two on

the top, to draw up the sap. And it is reported, that by grafting upon the bough of a tree, and cutting off some of the old boughs, the new cions will perish.* 4. To lay the roots bare for some few days about Christmas: which stops the ascent of the sap for a time; though it is afterward set free, by covering the root again with earth; whence the sap mounts the later.† 5. To remove the tree a month before it buds: for some time is required after the removal, to resettle it, before it can attract the juice; and that time being lost, the blossom must needs come later. 6. To graft roses in May, which gardeners seldom do till July; and then they bear not till the next year: but grafted in May, they will bear late the same year. 7. To gird the body of the tree with pack-thread; for this also, in some degree, restrains the sap, and makes it ascend later and slower.‡ 8. To plant them in a shade, or a hedge; for thus they are retarded, partly by want of sun, and partly by want of nourishment, on account of the hedges.‖ These

* This appears contrary to common experience.

† But does this cause the trees to bud or bear later afterwards?

‡ Will not the sap rise in plenty, though the tree were strongly girded?

‖ But will the rose-trees thus planted bear at all; for want of the sun, and proper nourishment?

means may be practised, both upon trees and flowers mutatis mutandis.*

SECT. XXII.

THE MELIORATION OF TREES, PLANTS, AND FRUITS.

It is matter of experience, that a heap of flint, or stone, laid about the bottom of a wild tree, as an oak, elm, ash, &c. makes it prosper twice as much as without it. The cause is, that it retains the moisture at any time falling upon the tree; suffers it not to exhale by the sun; and also defends the tree from cold blasts, and frosts, as it were in a house.† Perhaps too there is somewhat in keeping it steady at first. Let it be tried, if laying straw to some height about the body of the tree, will not make it

* How many of these probable means of procuring late flowers will stand good, after the method of rejection is practised upon them? Let it constantly be observed, that experiments well directed, afford as much light when they fail, as when they succeed. But it must be the philosopher, not the gardener, who reaps this fruit.

† One of the greatest inconveniences of this practice is affording a harbour to vermin; which might thus prove destructive to young trees.

come forwards. For though the root affords the sap, it is the body that must attract it. But if stones be laid about the stalks of lettuce, or other plants that are soft, the roots will be over-moistened, so that the worms will eat them.

A tree, at the first setting, should not be shook till it has fully taken root: whence some fix little forks about the bottom of their trees, to keep them upright;* but, after a year's rooting, shaking does the tree good, by loosening the earth, and perhaps by exercising, as it were, and stirring the sap. Generally, the cutting away of boughs, and suckers, at the root and body, makes the tree grow tall; as the polling and cutting off the top, makes them spread and grow bushy.

It is reported, that to hasten coppice-woods, the way is, to take willow, sallow, poplar, or alder, of seven years growth; and set them a-slope, a reasonable depth under ground: when, instead of one root, they will strike many; and so carry more shoots upon a stem.†

* Gardeners generally fasten their new planted trees to a stake with a hay-band, to prevent their being rocked by the wind; and continue them thus bound for some years, if they desire them to grow strait.

† Is this verified by experience?

To have many new roots of fruit-trees: bend a low tree, lay all its branches flat upon the ground; cast earth upon them; and every twig will take root.* This is a very profitable experiment in costly trees; for thus boughs will make stocks without charge. Try it in apricots, peaches, almonds, cornelians, mulberries, figs, &c. The like is constantly practised with vines, roses, musk-roses, &c,

From May to July, peel off the bark of any bough, for three or four inches; cover the bare place, somewhat above and below; with loam, well tempered with horse-dung; binding it fast down; then cut off the bough about Allhallow-tide, in the bare-place; set it, and it will grow to be a fair tree. The cause may be, that stripping off the bark keeps the sap from descending, towards winter; and so continues it in the bough. Perhaps also, the loam and horse-dung applied to the bare place, moisten, cherish, and make it more apt to put forth the root. And this may prove a general means to keep up the sap of trees in their boughs, for other purposes.†

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* Is this treatment successful in trees of all kinds, or only in some?

† The descending of the sap in trees, has been peremptorily denied by gardeners: but for a full account of this matter consult the Philosophical Transactions; French Memoirs; and Mr. Hales's Vegetable Statics.

It has been practised in trees that shew fair, yet do not bear, to bore a hole through the heart of them, to render them fruitful: in which case, the tree before might be too replete, and oppressed with its own sap; for repletion is an enemy to generation. It has also been practised in barren trees, to cleave two or three of the chief roots, and put a small pebble into the cleft, to keep it open; which makes the tree bear: for the root, as well as the body of a tree, may be bark-bound, and not keep open, unless somewhat be put into it.*

It is usual to set trees that require much sun, upon south walls; as apricots, peaches, plumbs, vines, figs, and the like. This has a double convenience; viz. the heat of the wall by reflexion; and the preventing the shade: for when a tree grows round, the higher boughs overshadow the lower; but when spread upon a wall, the sun comes alike, both upon the upper and lower branches.†

* These experiments are, in some cases, found to answer the end proposed: but they seem no general methods of rendering barren trees fruitful; each requiring a suitable remedy according to the particular cause of its barrenness.

† This method of planting against a south wall, is now extended to various fruit-trees; and found eminently serviceable.

It has also been practised, to strip off some leaves from the trees so spread, that the sun may come the better upon the boughs and fruit.* A tree has likewise been set upon the north-side of a wall to a small height, then drawn through the wall, and spread upon the south-side: that the root and lower part of the stock might enjoy the freshness of the shade; and the upper boughs and fruit the benefit of the sun. But it succeeded not; because the root requires some cherishing from the sun, though under the earth, as well as the body; and the lower part of the body more than the upper, as we find in compassing a tree below with straw.

The lowness of the fruit boughs makes the fruit greater, and causes it to ripen better;† for we always see in apricots, peaches, or melo-cotones upon a wall, the largest fruit is towards the bottom. And in France, the grapes that make the wine, grow upon low vines, bound to small stakes; whilst the raised vines, in arbors, only make verjuice.‡ It is true, in Italy, and

* This stripping off the leaves of fruit-trees, is observed to hasten the ripening; but to stint the growth of the fruit: for too much sun puts a period to growth; or ripens before the time.

† On account, perhaps, of the heat reflected from the earth; which reaches the lower boughs strongest.

‡ But is not this difference chiefly owing to the nature of the two several species?

other countries, where the sun is hotter, they raise them upon elms and trees; but I conceive, that if the French manner of planting low, were practised there, the wines would be stronger and sweeter: but it is more chargeable on account of the supporters. It were proper to try, whether a tree grafted somewhat near the ground, with the lower boughs only maintained, and the higher continually pruned off, would not make a larger fruit.*

To have plenty of fruit, the way is, to graft, not only upon young stocks, but upon several boughs of an old tree; for these will bear much fruit: whereas, if you graft but upon one stock, the tree can bear but little.†

To dig yearly about the roots of trees, as a means both to accelerate and meliorate fruits, is only practised in vines; but if transferred to other trees and shrubs, I conceive it would improve them likewise. A fruit-tree being blown up, almost, by the roots, and set again; it bore

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This is found to answer, when the branches of a tree are bent downwards, and thrown along a south wall.

† This is also a method of producing fruit quick, as in the first or second year; if the grafts be from good bearers. And hence we have an excellent way of converting old trees to profit; by letting them stand, instead of cutting them down for fewel, and planting new, which will be long before they attain their growth.

exceedingly the next year. This seems owing to the loosening of the earth, which refreshes any tree; and should be practised more than at present in fruit-trees: for trees cannot be so commodiously removed into new ground, as flowers and herbs.*

To revive an old tree, dig about its roots, and apply new mould thereto. We see that draught-oxen put into fresh pasture, get new and tender flesh: and in all cases, better nourishment than ordinary helps to renew; especially if it be not only better, but differing from the former.†

If an herb be cut off from its roots in the beginning of winter, and the earth be trod and beat down hard with the foot and spade, the roots will be very large in summer: for the moisture being thus kept from rising in the plant, stays longer in the root, and so dilates it. And gardeners commonly tread loose ground, after sowing onions, turnips, &c. Panicum laid below and about the bottom of a root, will cause it to grow excessively; for being itself of a spungy substance, it attracts the moisture of the

* This expedient of digging about the roots of trees, is chiefly practised in stiff and cold ground, and after the trees have stood for some years; lest it might otherwise subject them to be blown down by the winds.

† The soil may sometimes be too rich of itself: and then the addition of a poorer kind is an amendment.

earth, and so feeds the root. This is of principal use for onions, turnips, parsnips, and carrots.

The shifting of ground is a means to meliorate trees and fruits; but with this caution, that all things prosper best when advanced from worse to better.* Thus nurseries of stocks should be in a more barren ground, than that whereto they are removed; and all graziers remove their cattle from poorer pasture to richer. So hardiness in youth prolongs life; because it leaves the body improvable in age: and even in exercises, it is good to begin with the hardest, as dancing in thick shoes, &c.

Hacking of trees in their bark, both right down and across, so as to make rather slits than continued hacks, is highly serviceable to trees; prevents their being bark-bound, and kills the moss.†

Shade conduces to render some plants large and prosperous, more than the sun; as in strawberries, bays, &c. And therefore to sow bo-

* This caution admits of an exception, where the soil was too rich: in which case removing to a poorer, would render the tree more healthy and fruitful. Many of the rules of medicine seem to have place in vegetables.

† This is chiefly practised in trees of some years growth; and found very useful, especially when they are already bark-bound.

rage-seed thin among strawberries, will make the fruit under the borage-leaves far larger than their fellows.* And bays should be planted to the north, or defended from the sun, by a hedge-row: and when you sow the berries, weed not the borders for the first half year; because the weeds afford a proper shade.

To encrease the crops of vegetables, we must not only encrease the vigour of the earth, and of the plant; but also preserve what would otherwise be lost. Thus the late trial to set wheat, is now left off, because of the trouble and pains it required: yet there is much saved by setting, in comparison of sowing; as keeping the seed from being eat up by the birds, and avoiding the shallow lying of it, whereby much of what is sown, cannot take root.

It is reported, that if nitre be mixed with water, to the thickness of honey, and after a vine is cut, the bud be anointed therewith, it will sprout within eight days. If the experiment be true, the cause may lie in the opening of the bud, and contiguous parts, by the spirit of the nitre; for nitre is the life of vegetables.†

* But then the shade must not be large. Perhaps strawberries are best delighted with a mixture of sun and shade.

† How far this may be true, is not perhaps sufficiently shewn; notwithstanding the experiments of Sir Kenelm Digby, and M. Homberg. Consult Mr. Evelyn's Sylva;

Put any seed, or the kernels of apples, pears, oranges, the stone of a peach, a plumb, &c. into a squill; and they will come up much earlier than when sown in the earth itself. This I conceive is a kind of grafting in the root; for as the stock yields a better prepared nourishment to the graft than the crude earth; so does the squill to the seed. And I suppose the same would succeed, by putting kernels into a turnip, or the like; only that the squill is more vigorous and hot. It may be tried also, by putting onion-seed into an onion; which thereby, perhaps, will bring forth large and earlier.*

The pricking of fruit in several places, when almost full grown, and before it ripens, has been practised with success, to bring it sooner to maturity. The biting of wasps or worms upon fruit, causes it to ripen manifestly quicker. It is reported, that sea-weed, put under the roots of coleworts, and other plants, will forward their

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the Philosophical Transactions; the French Memoirs; and Dr. Stahl's Philosophical Principles of Chemistry: but a proper set of accurate experiments seem still wanting in this view.

* These experiments appear probable; but how they answer upon trial, should be particularly observed and recorded. They seem better fitted for the use of philosophers than gardeners; and therefore perhaps have not been fully prosecuted.

growth. The virtue, no doubt, has relation to salt, which greatly promotes fertility. *

It has been practised to cut off the stalks of cucumbers, immediately after their bearing, close by the earth; and then to throw a quantity of mould upon the remaining plant: which makes them bear fruit the ensuing year, long before the ordinary time. The cause may be, that the sap goes down the sooner, and is not spent in the stalk or leaf, remaining after the fruit. The dying of the roots of annual plants in the winter, seems partly owing to the profusion of sap in forming the stalk and leaves; which being prevented, they will superannuate, if they stand warm.

To pluck off many of the blossoms from a fruit-tree, makes the fruit fairer: the sap thus having less to nourish. And it is commonly observed, that if some blossoms be not plucked off the first time a tree blows, it will blossom itself to death.†

It were proper to try the effect of plucking off all the blossoms from a fruit-tree; or the acorns, chesnut-buds, &c. from a wild tree; for two

* See more to this purpose under the article *Maturation*.

† Especially if the tree be lately planted, and the root be weak.

years together. I suppose the tree would either yield fruit the third year, larger, and in greater plenty; or else, the larger leaves, in the intermediate years, because of the sap here treasured up.*

It has been generally received, that a plant watered with warm water, will come up sooner and better, than when watered with cold water, or showers. But our experiment of watering wheat with warm water did not succeed; perhaps because made too late in the year, viz. the end of October: for the cold then coming upon the seed, after being rendered more tender by warm water, might check it.

No doubt, but grafting generally meliorates the fruit; because the nourishment is better prepared in the stock, than in the crude earth.† Yet some trees are said to come up stronger from the kernel, than from the graft; as the peach and melo-cotone: perhaps because those plants require a nourishment of greater moisture. And though the nourishment of the stock be finer and better prepared; yet it is not so

* Has this experiment been duly made?

† Is this reason just? Do not the branches of an ungrafted tree receive their nourishment from the stock, as well as the graft does? Or does not the advantage of grafting depend upon the nature of the graft, and its being chose from a better tree than that whereon it is grafted?

moist and plentiful as that of the earth: and indeed we find those fruits very cold in their nature.

It has been received, that a smaller pear, grafted upon a stock bearing a larger pear, will become larger: but I judge that the cions will govern. Yet, probably, if you can get a cion to grow upon a stock of another kind, that is much moister than its own, it may make the fruit larger; because it will yield more nourishment; though perhaps coarser. But grafting is generally practised upon a drier stock; as the apple upon a crab; the pear upon a thorn, &c. Yet it is reported, that, in the Low-Countries, they will graft an apple-cion on a colewort-stock, and it shall bear a great flaggy apple; the kernel whereof if set, will prove a colewort, not an apple. It were proper to try whether an apple-cion will prosper, when grafted upon a sallow, a poplar, an elder, an elm, or a horse-plumb: which are the moistest of trees. I have heard it has been tried with success upon an elm.*

It is manifest by experience, that flowers removed, grow larger; because nourishment is more obtained in loose earth. Perhaps also,

* The business of grafting, and inoculation, require a strict physical enquiry; and a suitable variety of judicious and well calculated experiments.

frequently to regraft the same cions, may make the fruit larger; as if a cion were grafted upon a stock the first year; then cut off and grafted upon another stock the second year; and so the third or fourth; at last permitting it to rest; to try if when it bears, it will yield a larger fruit.*

If a fig-tree produce better figs, for having its tops cut off when its leaves begin to sprout, the cause is plain; the sap now having fewer parts to feed, and a less way to mount: but perhaps the figs will come somewhat later. The same may also be tried in other trees.†

It is reported, that mulberries will be fairer, and the trees more fruitful, if you bore their trunks through in several places, and force into the apertures, wedges of some hotter tree; as turpentine, mastich, guaiacum, juniper, &c. perhaps because the adventitious heat revives the native juice of the tree. It is also reported, that trees will grow larger, and bear better fruit, by having salt, wine-lees, or blood applied to the

* This is said to have been tried without success: the grafts still retaining their original nature.

† If this be practised on young trees; it makes them throw out large strong shoots, that are apt to continue for a season or two unfruitful.

root; these things being more forcible than ordinary composts.*

Herbs will become tenderer and fairer, if taken out of their beds, when newly come up; and removed into pots with better earth. Coleworts are reported to prosper exceedingly, and to be better tasted, if sometimes watered with water mixed with salt; or much rather with nitre; the spirit whereof is less heating.†

It is said, that cucumbers will prove more tender and excellent, if their seeds be steeped a little in milk: perhaps because the seed being mollified with the milk, is too weak to attract the grosser juice of the earth, and so takes only the finer. The same experiment may be made with artichoaks, and other seeds, in order to take away either their flashiness or bitterness.

It is reported, that cucumbers will be less watery, and more melon-like, if the pit where they grow be half filled with chaff; or small sticks; and earth be thrown upon them: for cucumbers extremely affect moisture; and are apt to over-drink themselves; which this procedure prevents.

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* These materials being extremely rich, are to be sparingly used; and, perhaps, chiefly in the winter.

† See M. Homberg's Experiments upon Vegetation, in the French Memoirs.

The terebration of trees not only makes them prosper, but also renders the fruit sweeter: for notwithstanding the perforation, they may receive sufficient nourishment; yet no more than they can well digest; and at the same time sweat out the coarsest and unprofitable juices, as in animals; which by moderate feeding, exercise, and sweat, attain the soundest habit of body. And as terebration meliorates fruit; for the like reason does the bleeding of plants, as by pricking the vine, or other trees, after they are somewhat grown; and thus letting out their gums or tears: though this be not to continue, as in terebration; but to be done only at certain seasons.* And it is reported that by this means, bitter almonds have been turned into sweet.

It is observed, that all herbs become sweeter, both in smell and taste, if, when grown up some seasonable time, they be cut; and the later sprout be chose. The reason may be, that the longer the juice continues in the root and stalk, the better it is concocted. For one chief cause why grain, seeds, and fruits, are more nourishing than leaves, is the length of time they require to ripen. It were not amiss to keep back

* For the method and uses of tapping trees, see certain Papers in the Philosophical Transactions; particularly No. 43, 48, 57, 58, 68.

the sap of herbs, by some proper means, till the end of summer; whereby perhaps they will become more nourishing.*

As grafting generally advances and meliorates fruits above what they are when produced from stones, seeds, or kernels, because the nourishment is better concocted, so in grafting itself, for the same cause, the choice of the stock contributes much, provided it be somewhat inferior to the cion, otherwise it obstructs. The grafting of pears and apples upon a quince is highly commended.†

Besides the above mentioned means for meliorating fruits, it has been tried, that a mixture of bran and swine's dung, or chaff and swine's dung, laid to rot for a month, greatly nourishes and supports fruit-trees.‡

It is said, that if the bough of a low fruit-tree, newly budded, be gently drawn, without hurting it, into an earthen pot, perforated at the bottom

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* This is an experiment of consequence; and requires that the best means should be thought of for trying it; whether by cold, ligature, want of moisture, or otherwise.

† See above, Sect. 25, 26.

‡ In the time of rotting, a considerable heat is generated, which might prove unsuitable to certain trees; but by the operation, the whole is turned into an uniform kind of mould. The history of vegetation requires a previous enquiry into the nature, office, and use of putrefaction.

to receive it, and then the pot be covered with earth, it will yield a very large fruit within the ground; which experiment is no more than potting of plants without removing, and leaving the fruit in the earth. The like, they say, may be effected by an empty pot, without earth in it, put over a fruit, supported as it hangs upon the tree, and the better if some few holes be made in the pot. In this experiment, besides defending the fruit from the extremity of the sun or weather, some assign for a reason, that the fruit coveting the open air and the sun, is invited by those holes to spread and approach as near them as it can, and thus enlarges in magnitude.*

All trees in high and sandy grounds are to be set deep, and in watery grounds more shallow. And in the removal of trees, especially fruit-trees, care should be taken that their sides be set north and south, &c. as they stood before.†

Timber-trees in a coppice, grow better than in an open field, because they spread not so much, but shoot up in height; and chiefly because they are defended from too much sun and wind, which check the growth of all fruit. And

* Though a large fruit may be thus procured, yet will it be so well ripened as another more exposed to the sun?

† Do gardeners find any necessity for observing this rule, or is any advantage certainly found in observing it?

thus, no doubt, fruit-trees or vines, set against a wall to the sun, between elbows or buttresses of stone, ripen the fruit better than a plain wall.*

It is said, that if potatoe-roots be set in a pot filled with earth, and the pot be set in the ground two or three inches deep, the roots will grow larger than ordinary. The cause may be, that having earth enough within the pot to nourish them, and being stopped by the bottom of the pot from shooting their strings downward, they grow more in breadth and thickness. And perhaps all seeds or roots potted, and so set in earth, will prosper better.

The cutting off the leaves of radish, or other roots, in the beginning of winter, before they wither, and covering again the root something high with earth, will preserve the root all winter, and make it larger the following spring; so that there is a double use of this cutting: for in plants where the root is esculent, as radish and parsnip, it will make it greater; and so it will the heads of onions:† and where the fruit is

* On account of the sun's rays reflected upon the fruit, and the general heat thus thrown by the stone elbows upon the trees.

† It is the common practice to plant celery in trenches, and cover it high with earth some time afterwards, in order to procure the greater length of the white esculent root.

esculent, it will, by strengthening the root, make also the fruit larger.

It is an experiment of great pleasure to make the leaves of shady trees larger than ordinary. It has been tried, that a clon of a weech-elm, grafted upon the stock of an ordinary elm, will put forth leaves almost as broad as the brim of a hat. And it is very likely, that as in fruit-trees the graft makes a larger fruit, so in trees that bear no fruit, it will make the leaves larger. It should therefore be tried in such trees as birch, asp, willow, and especially the shining willow called swallow-tail, for the pleasure of its leaf.*

The barrenness of trees by accident, besides the weakness of the soil, seed, or root, and the injury of the weather, proceeds either, 1. from their being overgrown with moss; 2. bark-bound; 3. planted too deep; or, 4. from the sap going too much into the leaves: for all which there are remedies mentioned above.†

* The graft being taken from such trees as afford the greatest foliage, and a proper stock made choice of.

† There may perhaps be many other causes of barrenness in trees besides those here enumerated, as blasts, insects, cold, wet, &c. all which require their particular remedies.

SECT. IV.

OF COMPOUND FRUITS AND FLOWERS.

In animals that have male and female there are several kinds of copulation, productive of compounded creatures; thus the mule is generated betwixt the horse and the ass, &c. The compounding or mixture of kinds in plants is not known, which however, if possible, were a thing more at command than in living creatures, where generation requires a voluntary motion. This would therefore be a capital experiment in vegetation, if discovered, for thus we might have great variety of fruits and flowers hitherto unknown. Grafting does not produce this effect, as only mending the fruit, or doubling the flowers, &c. without making any new kind, for the cion constantly over-rules the stock.*

It is anciently delivered, that two twigs of different fruit-trees, being flatted on the opposite sides, then bound close together, and set in the ground will come up in one stock, yet put forth

* Have the proper experiments for this purpose been hitherto tried, with the farina fœcundans of flowers, &c.?—See the French Memoirs for the year 1711, &c.

their several fruits without commixture in the fruit. Where note, that unity of continuance is easier to procure than unity of species. It is reported also, that vines of red and white grapes being set in the ground, and the upper parts being flatted and bound close together, will yield grapes of several colours within the same grape, but the more after a year or two, the unity, as it seems, growing more perfect. And it will also contribute, if from the first uniting they be often watered; for all moisture promotes union. It is also prescribed to bind the bud as soon as it comes forth, as well as the stock, at least for a time.*

They report, that different seeds, wrapped in a cloth, and laid in earth well dunged, will rise contiguous plants, which being afterwards bound together, their shoots will incorporate; and the like is said of kernels put into a bottle with a narrow mouth and filled with earth. So again, they say, that young trees of several kinds, set contiguous, without any binding, and very often watered in fruitful ground, will, through the very luxury of the trees, incorporate and grow together, which seems a more likely means, because

* These experiments seem to savour more of imagination than practice.

the binding hinders the natural swelling of the trees, which unite the better whilst in motion.*

SECT. V.

OF THE SYMPATHY AND ANTIPATHY OF PLANTS.

THERE are many received traditions about the sympathy and antipathy of plants, some thriving best when they grow near others, which is imputed to sympathy, and some worse, which is imputed to antipathy. But these are idle and ignorant conceits, that forsake the true indication of causes, as most experiments do concerning

* Though experiments of this kind, so slightly recommended either by reason or authority, may perhaps scarce deserve to be tried, yet they have this use, that they shew distress, and should excite the industry of philosophers to invent better for the purpose. Let the means of generation in plants be once exactly discovered, and experiments for compounding or mixing of their species will arise of themselves. Let particular enquiry be made into the fact delivered in the Philosophical Transactions, No. 29, p. 553 of the orange-trees at Florence that bear a fruit half citron, half orange, and are propagated by engrafting. The relation seems in a particular manner confirmed, illustrated, and explained, No. 114, p. 313, of the same Transactions.

sympathies and antipathies.* Plants have no such secret friendship or hatred; and to call it sympathy and antipathy is quite mistaking the thing, their sympathy being an antipathy, and their antipathy a sympathy: for whenever one plant attracts such a particular juice from the earth as qualifies the remainder for another plant, their proximity does good, because the nourishment of the two plants are contrary; and where two plants draw the same juice, their growing together, does hurt, because the one thus defrauds the other.

First, therefore, the plants that attract much nourishment from the earth, and so exhaust it, prejudice all things that grow near them; thus great trees, especially ashes, and such as spread their roots near the surface, are pernicious to other plants.† So the colewort is not an enemy to the vine only, but to any other plant, because it strongly attracts the fattest juice of the earth.‡ And if it be true, that the vine,

* See the article *Sympathy*.

† Especially if besides drawing away their nourishment they also overshade such plants.

‡ Is there certainly found to be an appetite of election in plants, whereby they attract one particular juice of the earth and refuse another? Or is there a sufficient variety of juices in the earth to feed all the different species of vegetables in the same garden or country?

when it creeps near the colewort, will turn aside, this may happen, because it there finds worse nourishment; for though the root be where it was, yet I suspect the plant will bend as it nourishes.

Where plants are of different natures, and attract different juices, there the one being set by the other is of service; as rue prospers and becomes stronger, if set by a fig-tree, which may proceed from the extraction of a contrary juice, the one drawing juice fit to become sweet, the other bitter. So, they say, that a rose set by garlic is sweeter; which likewise may happen, because the more fetid juice of the earth goes into the garlic, and the more odorate into the rose.*

It is manifest, that certain corn-flowers seldom or never grow in other places, unless they are set, but only among corn, as the blue-bottle, a kind of yellow marygold, the wild poppy, and fumitory. Nor can this proceed from the culture of the ground, by ploughing or furrowing, as some herbs and flowers will grow but in ditches new cast up; for if the ground lie

* Is there any certainty in these relations? Is the supposition of different juices in the earth confirmed, or do all plants make their own juices respectively from one or more common juices of the earth?

fallow and unsown, they will not come: whence it should seem to be the corn that qualifies the earth, and prepares it for their growth.*

If the foregoing observation holds, it is of great use for meliorating the taste of fruits, esculent herbs, and the scent of flowers. For if the fig-tree makes the rue stronger and bitterer, rue plentifully planted about the fig-tree, may make the fig sweeter. And as the tastes that offend in fruits, herbs, and roots, are bitter, harsh, sour, and waterish, it were proper to make the following trials:—1. Set wormwood or rue near lettuce, cauliflower, or artichoke, to try whether these will become sweeter. 2. Take a service-tree, a cornelian, or alder, whose fruits have a harsh and astringent juice, and set them near a vine, or fig-tree, to find whether the grapes or figs will thus be the sweeter. 3. Set cucumbers or pompions among musk-melons, to see whether the melons will not be more vinous and better tasted. 4. Set cucumbers also among radish, to try whether the radish will be the more biting. 5. Set sorrel among rasberries, to see whether the rasberries will be the sweeter. 6. Set common briar among violets or wall-flower, to see whether it will make the violets or wall-flowers

* Are not the seeds of these flowers sown along with the corn?

sweeter, and of a less earthy odour. 7. So set lettuce or cucumbers among rosemary or bays, to try whether the rosemary or bays will become more aromatic. 8. On the other hand, beware of setting such plants together as draw nearly the same juice. I suspect rosemary would lose part of its sweetness if set with lavender, bays, or the like. 9. Yet to correct the strength of an herb, others of like kind may be set near to lower it; thus tansy set by angelica may be made weaker, and fitter for mixture in perfumes; and rue set by common wormwood might become liker to Roman wormwood.*

Trial should also be made in poisonous and purgative herbs, whose ill qualities might perhaps be discharged or corrected, by setting stronger poisons or purgatives near them. It is reported, that the shrub called ladies-seal (which is a kind of briony) and coleworts, if set near each other, one or both of them will die, being, I suppose, depredators of the earth, so that one of them

* These experiments being here only recommended upon the preceding supposition, that plants, according to their several natures, attract different juices from the earth, have not, perhaps, been made with sufficient attention. The advantage to be expected from the direct experiments are no sufficient recommendation of them to gardeners; but they have a higher use in assisting to determine whether there are different kinds of juices in the earth.

starves the other. The like is said of the reed and the brake, both which are succulent, and therefore the one may defraud the other. Understand the like of hemloc and rue, both which attract strong juices.*

Many who have laboured in natural magic observe a sympathy between the sun, moon, some principal stars, and certain plants; whence they have denominated some herbs solar, some lunar, and delivered such trifles in lofty language. It is manifest that some flowers have two respects to the sun, the one by opening and shutting, the other by bowing and inclining their heads: for marygolds, tulips, pimpernel, and most flowers open their leaves when the sun shines clear, and in some measure close them either towards night, or when the sky is overcast. Of this there needs no such solemn reason as that such plants rejoice in the presence and mourn in the absence of the sun; the cause being no more than a little moisture of the air, which loads the leaves, and swells them at the bottom, whereas the dry air expands them. And some make it a wonder that garden-clover should hide the stalk when the sun shines bright, though this be nothing but a

* Perhaps the certain fact in these matters is not hitherto fully discovered, for want of sets of proper trials, repeated with due attention and accuracy.

full expansion of the leaves. The plants that bow and incline the head are the great sun-flower, marygold, wartwort, mallow-flowers, &c. The cause of this is somewhat more obscure than the former, but I take it to be no other than that the part against which the sun beats grows weaker and more flaccid in the stalk, and thence becomes less able to support the flower.*

What effect a little moisture may have upon vegetables, even though dead and severed from the earth, appears in the experiment of jugglers; who take the beard of an oat, which is wreathed at the bottom, and a smooth entire straw a-top. chusing only the wreathed part, and cutting off the other, so as to leave the beard half an inch long. Next they make a little cross of a quill, lengthwise of that part of the quill which has the pith, and crosswise of that part which has none, the whole cross being half an inch high. Then they prick a hole in the bottom where the pith is, and put the oaten-beard therein, leaving half of it sticking out of the quill. Now they take a little wooden box (as if somewhat in the box did the feat), in which, with a pin, they make a small hole, to receive the beard, without letting

* Whence proceeds that extraordinary phenomenon of the sensitive or humble plant, which falls flat upon being touched, and afterwards gently rises again?

the cross sink down. Lastly, they ask the question as—Which is the fairest woman in the company? or the like; and at every question they stick the cross in the box, having first put it towards their mouth, as if they charmed it, and the cross stirs not; but when they come to the person they design, as they hold the cross to their mouth, they wet the beard with the tip of their tongue, and so stick the cross in the box, upon which it turns softly round three or four times, by the untwining of the beard from the moisture.* This becomes more evident if you stick the cross between your fingers. Whence it appears, that the motion produced by so little moisture is stronger than the closing or bending of the head of a marygold, &c.

It is reported that the herb rosa solis, will at noon-day, when the sun shines hot and bright, have a great dew upon it; and therefore that the right name is ros solis. This they impute to a sympathy it has with the sun. Men favour wonders. It were proper first to be sure that the dew found upon it is not the dew of the morning preserved, when the dew of other herbs is

* This property of the oat-beard, to move with so little moisture, has occasioned it to be chosen for making an hygrometer, to shew the degree of moisture in the air, after the manner of the hand of a dial.

breathed away; for it has a smooth and thick leaf, which does not discharge the dew so soon as other herbs that are more spungy and porous;* and perhaps purslane, or some other herb, does the like. But if it has more dew at noon than in the morning, then it seems to be an exudation of the herb itself, as plumbs sweat when put into the oven.

It is certain, that honey-dews are found more upon oak-leaves than upon ash, beech, or the like; but whether the leaf has any property of concocting the dew, or whether the thing happens only on account of the closeness and smoothness of the leaf, seems doubtful. It should be well examined, whether manna falls upon certain herbs or leaves.† Flowers that have deep sockets gather in the bottom a kind of honey, as honey-suckles, lilies, and the like.‡ And in these the flower bears a part with the dew.

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* An accurate observation of the structure of this plant might perhaps lead to a discovery of the whole mystery. No notice is here taken that the leaves are somewhat hollow, covered all over and fringed at the edges with a kind of fine, short, red hairs, which give the whole leaf a red cast.

† See the article *Manna*.

‡ And is not this sweet substance a particular exalted juice of the plant, and the real honey which bees only collect from flowers, and treasure up in their hives.

The froth called cuckow-spittle is found only upon certain hot herbs, as lavender, sage, hyssop, &c. Enquire into the cause thereof, for it seems a secret.* Mildew also falls upon corn, and smuts it; but the same also falls upon other herbs, though it is less observed.

Let it be tried whether the great consent betwixt plants and water will cause an attraction at a distance as well as in contact. In the middle of a vessel make a false bottom of coarse canvas; fill the vessel with earth above the canvas, and let the earth be kept dry; then sow some good seed in this earth; and under the canvas, half a foot in the bottom of the vessel, place a large spunge thoroughly wet in water, and let it lye for ten days, to try whether the seeds will sprout, the earth become moister, and the spunge more dry.†

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* Is there not constantly found an egg, aurelia, small worm, or maggot within this frothy matter? By what creature is this egg laid, and into what does it turn? Of what nature is the froth; from whence does it proceed; what is its use; and how comes it not to exhale with the heat of the sun? Lastly, is it found only upon aromatic plants?

† Has this experiment been satisfactorily tried?

SECT. VI.

OF RENDERING FRUITS AND HERBS MEDICINAL.

ATTEMPTS for altering the scent, colour, or taste of fruit, by infusing, mixing, or putting into the bark, root, herb, or flower, any aromatical, coloured, or medicinal substance, are but fancies; for these things have passed their period, and nourish not.* And every alteration of vegetables in those qualities must be effected by means of somewhat that is apt to enter the nourishment of the plant. It is certain, that where cows feed upon wild garlick, their milk tastes plainly of it; and mutton is better tasted when the sheep feed upon wild thyme, and other wholesome herbs. Galen speaks of curing a schirrous liver by the milk of a cow that feeds upon certain herbs. The honey in Spain smells of the rosemary or orange-tree from whence it was gathered; and there is an old tradition of a courtezan fed with napellus, which, though accounted the strongest vegetable poison, yet, through use did not hurt her, but by communi-

* This is an approximation to a very considerable axiom.

cation poisoned some of her gallants. There is observed an efficacious bezoar, and another without virtue, though they appear alike; but the efficacious one is taken from the beast that feeds where there are antidotal herbs; and that without virtue, from such as feed where no such herbs grow. Again, steeped wines and beers are very medicinal, as likewise bread mix'd with powders; so meat also, as flesh, fish, milk, and eggs, may perhaps be made of great use for medicine and diet, if the beast, fowl, or fish be fed with a particular kind of food proper for the disease.* This were dangerous doctrine with regard to secret poisoning. But whether it may be applied to plants, I question the rather because their nourishment is a more common juice, scarce capable of any particular quality before the plant assimilates it.†

* Numerous capital instances to this purpose might be collected from the Philosophical Transactions, French Memoirs, German Ephemerides, and Mr. Boyle's Philosophical Writings.

† Hence it appears that the author does not suppose the different juices of vegetables formally to exist in the earth, but that they receive their several particular properties and virtues from the action or elaboration of the respective plant. So that what is above delivered, as to plants attracting different juices from the earth, is to be understood of crude, and not of concocted juices, as they are found in the vessels of vegetables. See above, Sect. V.

But lest our incredulity should prevent any profitable operations of this kind, especially since many of the ancients have set them down, we will briefly touch upon the four means they have devised for making plants medicinal. The first is by slitting the root, and infusing the medicine therein, as hellebore, opium, scammony, theriaca, &c. then binding it up again. This seems the less promising, because the root draws immediately from the earth, and so the nourishment is still common, and less qualified for the end proposed. Besides, it is thus a long time before the medicine reaches the fruit. The sesond is, to perforate the body of the tree, and then to infuse the medicine, which is somewhat better; for if any virtue be received from the medicine, it has thus the shorter and quicker ascent. The third is, to steep the seed or kernel in some liquor wherein the medicine is infused; which I have little opinion of, because I suspect the seed will scarce draw the parts of the matter that have the property; but it may be much more promising to mix the medicine with dung, because the seed naturally drawing the moisture of the dung, may receive some of the property along with it. The fourth is, the frequent watering of the plant with an infusion of the medicine. This in one respect may have more force than the rest, because the means is

frequently renewed, whereas the rest are applied but once, whence the virtue may the sooner vanish. But still I suspect the root is somewhat too stubborn to receive such fine impressions, which have also a great way to ascend. I judge therefore the likeliest method to be the perforation of the body of the tree in several places one above another; then the filling of the holes with dung mixed with the medicine, and watering these parcels of dung, by means of squirts, with an infusion of the medicine in dunged water, once in three or four days.*

SECT. VII.

OF CURIOSITIES IN VEGETATION.

It is a curiosity to have several fruits upon one tree, especially when some of them come

* It were easy to derive a particular experiment for trial, from the preceding doctrine, but it requires a philosophical disposition to make it. Few gardeners would think it worth their while to keep constantly watering a plant with a solution of opium, a tincture of cinnamon, a decoction of coloquintida, &c. for months together. But unless some such experiments are tried with care and judgment, our reason will never inform us what effects are producible in this way.

early and some late, so that the same tree shall bear ripe fruit all the summer. This is easily effected by grafting several cions upon several boughs of a stock, in a good ground, and plentifully fed: thus you may have all the kinds of cherries, or of plumbs, peaches, or apricots upon one tree. But I conceive the diversity of fruits must be such as will graft upon the same stock, and therefore question whether apples, pears, or oranges may be procured upon the same stock whereon plumbs are grafted.*

It is also a curiosity to have fruits of several shapes and figures. This is easily procured by fashioning them, when the fruit is young, with moulds of earth or wood. Thus you may have cucumbers, &c. as long as a cane, as round as a ball, or formed like a cross. You may also have apples in the form of pears or lemons. You may thus likewise have fruit in the more curious figures of men, beasts, birds, &c. the moulds being made large enough to contain the whole fruit when grown to its full size, otherwise you will

* It is commonly found that the several fruits of the same species, but not different species, are producible by engrafting on the same tree. Thus it has in vain been tried to produce nuts, cherries, apples, figs, &c. all upon one stock. If this be constantly and invariably the case, what is the true physical cause thereof?

stop its spreading, so as not to fill the concavity, and receive the shape desired, as happens in mould-works of fluid bodies. Some doubt may arise, that thus keeping the fruit from the sun may hurt it; but we find by common experience that fruit will grow when covered. Perhaps also some small holes may be advantageously made in the mould, to let in the sun. And it were best to make the mould in two separable parts, and glew or cement them together, that they may be opened to take out the fruit.*

It is a curiosity to have inscriptions or engraving appear on fruit or trees, which is easily procured by writing upon young trees or fruits with a needle, bodkin, or carving with a knife; for as they grow, so will the letters grow more large and graphical.†

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* These experiments have been found to succeed with regard to the shapes of the fruit, though not so well perhaps with regard to its goodness.

† This appears to have been an ancient practice, and a kind of amusement for lovers.

——— "Tenerisque meos incidere amores
Arboribus; crescent illæ, crescetis amores."

It has also been used upon other occasions. There goes a report of a certain pear-tree that had the name of James, or Ormond, upon all its fruit. The manner how this was procured, if different from that above, may deserve the enquiry.

Trees may be adorned with flowers or herbs, by boring their bodies, and putting into the holes earth mixed with manure, and setting seeds, slips of violets, strawberries, wild thyme, camomile, or the like, therein; for they will thus grow in the trees as in pots, though perhaps they receive some additional nourishment from the trees.* The experiment might also be tried with shoots of vines and the roots of red roses, for these being of a more woody nature, will perhaps incorporate with the tree itself.

It is a common curiosity to bring trees and shrubs into various shapes, by moulding them within and cutting them without. But these are imperfect things, being too small to keep their figure. Large castles made of trees upon timber frames, with turrets and arches, were anciently matters of magnificence.

Among curiosities comes coloration, for the pre-eminence in flowers is beauty. It is observed, that July-flowers, sweetwilliams, and violets, that are coloured, if they be neglected, and neither watered, new moulded, nor transplanted, will turn white; and probably the white, with much culture, may turn coloured: for the white colour proceeds from scarcity of nourishment,

* Observe for this purpose to bore the holes somewhat sloping downwards, that the mould and moisture may lodge.

except in flowers that are only white, and admit of no other colour. It is proper therefore to see what natures accompany what colours, whence light may be had to induce colours, by producing those natures.* Whites are more inodorous than flowers of the same kind coloured, as in single white violets, white roses, white July-flowers,† &c. Blossoms of trees also, that are white, commonly prove inodorous, as cherries, pears, plumbs; whereas those of apples, crabs, almonds, and peaches are blushy, and smell sweet. The cause is, that the substance which makes the flower is the thinnest part of the plant; whence also flowers are of such curious colours; and if this be too sparing and thin, it attains no strength of odour, except in such plants as are very succulent, which should therefore rather be stinted in their nourishment than replenished, to make them sweet, as we find in white satyrion, which is of a curious odour, and in bean-flowers, &c. Again, if the plant put forth white flowers only,

* See this subject prosecuted by Mr. Boyle, in his Experimental History of Colours.

† Perhaps the reverse of this observation is true, or the contradictory instances numerous. Compare the white lily with the yellow; the white musk-rose with the red; white jessamin with the yellow; the white blossoms of the pear, the cherry, and the plumb-tree, with the variegated ones of the peach, nectarine, apple, &c.

and those not thin or dry, they are commonly of a rank and fulsome odour, as in May-flowers, white lilies, &c.

On the contrary, in berries, the whites are commonly more delicate, and sweet of taste than the coloured, as white grapes, white rasberries, white strawberries, white currans,* &c. The cause is, that the coloured are more succulent, of coarser juices, and not so well concocted; whilst the white are better proportioned to the digestion of the plant.

But in fruits, the white commonly are the coarsest, as in pear-plumbs, damascenes, &c. and the choicest plumbs are black; the black mulberry is better than the white. The harvest white plumb is coarse, and the verdoccio and white date-plumb not very good, as being too watery; whereas a higher concoction is required for sweetness, and therefore all fine plumbs are a little dry, and easily part from the stone, as the musk-plumb, the damascene-plumb, the peach, the apricot, &c. Yet some fruits which grow not to be black, are of the nature of berries, sweetest when pale, as the heart-cherry, which inclines more to white, is sweeter than the red, but the morelli more sour.†

* The contradictory instances should also be enumerated.

† These particulars, before they can be well adjusted,

Sow clove July-flower seed of one only kind, and it will produce flowers of different colours, as the seed casually meets with nourishment in the earth; whence the gardeners find two or three roots among a hundred that are rare and of great price, as purple, or carnation of several stripes: for there are very different juices in the earth, though contiguous, and in one bed,* and as the seed meets with them, so it sprouts. And those that come up purple always come single, the juice, as it should seem, not being able to allow a succulent colour and a double leaf. This experiment of several colours produced from the same seed should be tried also in larks-foot, monks-hood, poppy, and hollyoak.

Few fruits are red within, except the queen-apple, the rose-apple, mulberries, and red grapes, though this is chiefly towards the skin. There is a

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seem to require a further enquiry into colours, and the origin and causes of forms, than is hitherto extant.

* Can these different juices be extracted by a proper chemical contrivance, and exhibited distinct to the eye? And supposing this difference of juices, how do they act in causing a difference of colour in the flowers? Or, lastly, may not this difference of colour proceed from some particular in the seed, though of the same general kind with the rest? No exact solutions of such queries are to be expected without a rigid inductive enquiry, which few philosophers seem disposed to enter upon.

peach also that has a circle of red towards the stone; and the morelli-cherry is somewhat red within; but no pear, plumb, or apricot, though they have red sides, are red within.*

The general colour of plants is green, which no flower is, though there be indeed a pale greenish primrose. The young leaves of some trees turn a little reddish, as in oaks, vines, and hazles. Leaves rot into a yellow, and some hollies have part of their leaves yellow, that appear as fresh and shining as the green. Yellow also seems to be a less succulent colour than green, and a degree nearer to white. For it has been noted, that these yellow leaves of holly always stand towards the north and north-east. Some roots are yellow, as carrots; and some plants blood-red, stalk and leaf, as the amaranthus. Some herbs incline to purple and red, as a kind of sage, a kind of mint, rosa solis, &c. And some have white leaves, as another kind of sage, and another kind of mint; but azure and a fair purple are never found in leaves,† which shews that flowers are made of a refined juice of the

* Enquire into the colour of the blood-red tinging grape, the prickly pear, &c.

† By way of contradictory instances, remember the vetch, the garden or field violet, the passion-flower, the viola tricolor, &c.

earth as well as fruits, but the leaves of a more coarse and common one.*

It is a curiosity to make flowers double. This is effected by often removing them into new earth; as, on the contrary, double flowers, by neglect and want of removing, become single. The speedy way is, to sow or set seeds or slips of flowers, and as soon as they come up, to remove them into good new ground.† Enquire also whether inoculating of flowers, as stocks, roses, musk-roses, &c. does not make them double.‡ There is a cherry-tree that has double blossoms, but it bears no fruit; and perhaps the same means which, applied to the tree, greatly accelerate the sap in rising and breaking forth, will make the tree spend itself in flowers, and those double, which would be beautiful in apple-trees, peach-trees, and almond-trees, that have blush-coloured blossoms.

The producing of fruits without core or stone is likewise a curiosity, and somewhat more, be-

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* See the article *Percolation*.

† This is found to answer upon trial, especially when some of the flowers are plucked off, that the rest may thrive the better.

‡ The gardeners declare it does not, the bud inoculated constantly retaining its own nature, as in the case of graft-ing.

cause whatever has this effect may render them more tender and delicate. But the methods hitherto proposed for this purpose are generally trifling and insufficient.*

* These methods turn upon preventing the growth or increase of the pith of the tree, from whence the stone and core of the fruit have been supposed to proceed; constantly watering with warm water; grafting a sour fruit upon a sweeter stock; and all the known means of converting wild trees into garden ones. But nothing of this kind is said to be effectual. And indeed this business of exossiculation appears difficult, and, if performed, might be a capital instance of the human power over nature. An instance of approximation we have in the castration of animals, which makes them thrive better, and grow fatter. Were it not for such instances, the undertaking might seem desperate, as tending to deprive the fruit of its seed; and weakening, crossing, and destroying, instead of strengthening, invigorating, and co-operating with nature. But what instances of encouragement are there in vegetables themselves? Barberries have been sometimes found without stones, but then they usually appear in a shrunk or withered state. The instances of this kind should be collected, and the proper manner and time of castration thought of in imitation of the operation in living creatures, till a more commanding knowledge be gained of the nature and forms of vegetables.

SECT. VIII.

OF THE GENERATION OF PLANTS, AND THEIR TRANSMUTATION INTO ONE ANOTHER.

IT is certain that plants, for want of culture, degenerate, and sometimes so far as to change into another kind.* Long standing, without removal, makes them degenerate. Drought, unless the earth be moist, has the like effect; so has removing them into worse earth, or forbearing to manure the ground. Thus water-mint turns to field-mint, colewort into rape, &c. Whatever fruit thrives upon a root or a slip, will degenerate if it be sown. Grapes, figs, almonds, and pomegranate-kernels sown, make the fruits degenerate and become wild. Again, most of those fruits that use to be grafted degenerate if set of kernels or stone. Peaches indeed succeed better from the stone than upon grafting;† and the rule of exception seems to be this, that whatever plant requires much moisture, prospers bet-

* It deserves to be carefully observed, whether plants, by degenerating actually change their species.

† But if inoculating be used instead of grafting, the case is otherwise.

ter upon the stone or kernel than upon the graft; for the stock, though it gives a finer nourishment, yet gives less than the earth at large. Seeds, if very old, and yet of strength to produce a plant, make the plant degenerate; therefore skilful gardeners try their seeds before they buy them by putting them into water as it is gently boiling, for, if good, they will new sprout within half an hour.*

There goes an opinion, that if the same ground be often sown with the same grain, the grain, in the end, becomes of a baser kind. In very barren years, the corn that is sown becomes of a different kind.† And it is a rule, that plants produced by culture, as corn, will sooner change into another species than those that come of themselves, for culture gives but an adventitious nature, which is more easily put off.‡

The transmutation of plants one into another is a capital work of nature, the transmutation of species being pronounced impossible: it is a

* The heaviest seeds, or such as sink the fastest in water, are usually esteemed the best for sowing.

† Grandia sæpe quibus mandavimus hordia sulcis,
Infelix lolium, & steriles dominantur avenæ.

‡ These particulars require to be diligently examined into. See Dr. Sharrock's History of the Propagation and Improvement of Vegetables by the Concurrence of Art and Nature. Page 28, &c.

thing of difficulty, and requires deep search into nature; but as there appear some manifest instances of it,* the opinion of impossibility is here to be rejected, and the means to be sought.

In order to change one plant into another, the nourishment must over-rule the seed, and therefore the thing should be attempted by nourishment, as contrary as possible to the nature of the plant, yet so as it may grow, and with seeds of the weakest sort, or that have the least vigour. It were therefore proper to plant sedgy herbs in hilly or champaign ground, and such herbs as require much moisture, upon sandy and very dry ground: for example, marsh-mallows and reeds, upon hills; cucumbers, lettuce, and colewort, upon sand. On the other hand, plant bushes, heath, ling, and brakes, in wet or marshy ground. I conceive, likewise, that all esculent and garden herbs, set upon the tops of hills, prove more medicinal, though less esculent than before.† Perhaps also some wild herbs will make sallad-herbs. This is the first rule for the transmutation of plants.

The second rule may be, to set some few seeds

* Let these instances be enumerated, and carefully examined as to their certainty and justness.

† How is this found upon the hills about Montpellier, in France?

of the herb to be changed among other seeds, to try whether the juice of these other seeds will not so qualify the earth as to alter the seed to be operated upon: for example, sow parsley-seed among onion-seed, or lettuce-seed among parsley-seed, and try if by this means there will be any change of taste, or otherwise. But it were proper to separate the seed designed to be changed from the foreign seed, by the interposition of a piece of linen.

The third rule may be, the making some mixture of earth with other plants bruised, either in leaf or root; for example, make up earth with a mixture of colewort-leaves, and set artichoaks or parsnips in it; or take earth mixed with marjoram, origanum, or wild thyme bruised, and set in it fennel-seed, &c. It is not here designed that the herb to be wrought upon should draw the juice of the foreign herb, but I conceive there will be a new preparation of mould, which perhaps may alter the seed from the kind of the former herb.

The fourth rule may be, to mark what herbs some earths produce spontaneously, and to pot or vessel up that earth, and in it set the seed you would change. Thus take earth from under walls, or the like, where nettles grow in abundance, without any string or root of the nettles; pot that earth, and set in it stock-july-flowers or

wall-flowers, or sow the seeds of them therein, and try the event. Or take earth prepared to put forth mushrooms of itself, and sow therein purslane or lettuce-seed; for in these experiments it is probable that the earth, being accustomed to afford one kind of nourishment, will alter the new seed.

Let the fifth rule be, to make the herb grow contrary to its nature, as to make ground herbs rise in height. Thus carry camomile, wild thyme, or the green strawberry upon sticks, as they do hops upon poles, and observe the issue.

Let a sixth rule be, to make plants grow out of the sun's reach; for this is a great change in nature, and may induce a change in the seed. Thus barrel up earth, sow some seed in it, and place it at the bottom of a pond, or a great hollow tree. Try also the sowing of seeds in the bottoms of caves, and pots with seeds sown, hung in wells, some distance from the water, and observe the event.*

* Observe that these are not proposed as perfect rules, which, put in practice, shall certainly produce the effect; but only as attempts, by means of certain well adapted experiments, to discover such rules.

SECT. IX.

OF THE TALLNESS, LOWNESS, AND ARTIFICIAL DWARFING OF TREES.

TIMBER-trees, in coppice woods, grow more upright, and freer from under boughs, than those in the field, vegetables having a natural motion of rising to the sun. Besides, they are not glutted with too much nourishment, because the coppice shares with them, and repletion always hinders stature.* Lastly, they are kept warm, which, in plants, constantly promotes their mounting.

Trees that are full of heat, which appears by their inflammable gums, as firs and pines, mount in height, without shooting out side boughs till towards the top. The cause is, partly heat, and partly tenuity of juice, both which drive the sap upwards. As for juniper, it is but a shrub, and grows not large enough in the body to maintain a tall tree.

It is reported, that a strong canvas spread over a low-grafted tree, soon after it shoots, will dwarf

* Is this axiom sufficiently verified? If it be, it affords a rule for producing considerable effects.

it, and make it spread. The cause is manifest, for all things that grow must grow as they find room.*

Trees are generally set from roots or kernels; but if from slips, as particularly the mulberry, some of the slips will grow, and, it is said, become dwarf trees, because a slip draws nourishment weaker than a root or kernel.†

All plants that put forth their sap hastily, have their bodies not proportionable to their length, and are therefore winders and creepers, as ivy, briony, hops, woodbine, &c. whereas dwarfing requires the sap to rise slow, and a less vigour in mounting.

SECT. X.

OF THE RUDIMENTS AND EXCRESCENCES OF PLANTS.

SOLOMON wrote a natural history from the cedar of Lebanus to the moss growing upon the wall. And indeed moss is but the rudiment of

* This experiment is found to answer; so that fruit-trees may be thus dwarfed to advantage, and also have their fruit preserved both from the scorching sun and the birds.

† Do not those trees that will grow from slips, naturally become dwarfs, if all their side-shoots are suffered to grow without cutting?

a plant, growing chiefly upon the ridges of houses, whether tiled or thatched, and upon the crests of walls; and this moss is of a lightsome and pleasant green. It grows upon slopes, because, as it proceeds from moisture and water, so the water must slide, and not stand or stagnate. And its growing upon tiles or walls, &c. proceeds from hence, that those dried earths, having not moisture sufficient to put forth plants, practice germination by putting forth moss; tho' when by age or otherwise, they relent and resolve, they sometimes put forth plants, such as wall-flowers. And almost all moss has here and there little stalks, beside the low thrum.

Moss grows upon walks, especially as such as are cold, and exposed to the north, as in divers terraces, if they be trodden, or if they were at first gravelled; for wherever plants are kept down, the earth puts forth moss.

Old ground that has long lain fallow gathers moss; whence husbandmen cure their pasture-grounds, when they grow to moss, by tilling them for a year or two; which also depends upon the same cause, as the more sparing and starving juice of the earth, which is insufficient for plants, breeds moss. And old trees are more mossy than young ones, the sap being not so vigorous as all to rise to the boughs, but grow languid by the way, and puts out moss.

Fountains have moss growing about them; for fountains drain the water from the adjacent ground, and leave but sufficient moisture to breed moss, whereto the coldness of the water also conduces.

The moss of trees is a kind of hair, or the juice of the tree secreted that does not assimilate; and upon great trees, the moss grows in a figure like a leaf.

The moister sort of trees yield little moss, as asps, poplars, willows, beeches, &c. partly because of the quick rising of the sap into the boughs, and partly because the barks of these trees are more close and smooth than those of oaks and ashes, whence the moss can hardly issue out.

All fruit-trees grow full of moss in clay grounds, both upon the body and boughs, partly from the coldness of the ground, whence the plants are nourished less, and partly from the toughness of the earth, whereby the sap is confined, and cannot get up to spread freely.

We have already observed, that if trees be bark-bound, they grow less fruitful, and gather moss, and that they are cured by hacking,* &c. On the contrary, if trees be bound in with cords, they will put forth more moss, which also happens to trees that stand bleak. It should also

* See above, Sect. III.

be tried, whether a tree covered somewhat thick upon the top, after polling, will not gather more moss. I judge also, that to water trees with cold spring-water, makes them grow mossy.

The perfumers have a moss yielded by the apple-tree, and of an excellent odour.* The manner of its growth and nature should be enquired after. For the sake of this moss, it being a thing of price, I have above set down the ways of multiplying mosses.†

Next to moss come mushrooms, which are likewise an imperfect plant. Mushrooms have two strange properties; the one, that they yield a delicious meat; the other, that they come up in a night, and yet are unsown. They must necessarily, therefore, be made of much moisture; and that moisture fat and gross, yet somewhat concocted. And indeed we find that mushrooms cause what they call the incubus, or nightmare, in the stomach, whence a surfeit of them may suffocate and poison.‡ This shews they are windy, and that windiness gross and swelling,

* This moss seems to be a casual thing upon apple-trees, that is not often to be found, and perhaps depends on a certain small degree of putrefaction in the moss.

† There is a curious account of the mosses in Scotland, to be found in the Philosophical Transactions, No. 330.

‡ There are several species of mushrooms; but have the red-gilled species ever been found poisonous, pernicious, or surfeiting?

not sharp or griping. And for the same reason, mushrooms are provocative.

It is reported, that the bark of white or red poplar, cut small, cast into furrows, and well dunged, will cause the ground to put forth mushrooms, at all seasons of the year, fit for eating. Some add to the mixture bakers' leaven dissolved in water. And it is said, that if a hilly field, where the stubble is standing, be set on fire in a showery season, it will afford great store of mushrooms. It is also said, that hartshorn-shavings mixed with dung, and watered, yield mushrooms; and hartshorn is of a fat and clammy substance: perhaps ox-horn would do the like.*

There is no known substance but earth, and the produces thereof, as tiles, stones, &c. that yields any moss or herby substance. Trial may be made, by putting seeds into little holes bored in the horns of stags or oxen, to see if they will grow.†

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* Great light is given to this whole affair of mushrooms, by the Memoirs of the Royal Academy of Sciences at Paris. See in particular, for the year 1707. Hist. p. 46. and Memoir. p. 58.

† What are the instances of approach in this case? Consider of the vegetation upon the white cake of salt left after the distillation of Glauber's spirit of nitre. Consider also the growth of mushrooms upon chirurgeon's dressings, &c. See the French Memoirs in the places above quoted.

There is another imperfect plant, to appearance a great mushroom, sometimes as broad as a hat, and called a toad's-stool; but it is not esculent, and commonly grows adjacent to the dead stump of a tree, or the roots of rotten trees, and therefore seems to take its juice from putrefied wood. Which shews, by the way, that putrefied wood yields a free moisture.*

There is a nameless cake that grows upon the side of a dead tree, large, of a chesnut colour, hard and pithy;† whence it should seem that even dead trees continue to put forth, as the dead bodies of men do hair and nails for a time.

There is a bug, or fuzzy ball, growing common in the fields, that at the first is hard, like a tennis-ball, and white, but after grows of a mushroom-colour, and full of light dust upon the breaking. It is thought to be dangerous to the eyes, if the powder gets into them, and good for kibes, being probably of a corrosive and fretting nature.‡

There is an excrescence, called jew's-ear, that grows upon the roots, and lower parts of trees,

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* See Philosophical Transactions, No. 330.

† Is not this leather-like excrescence somewhat analogous to the nostoc, or star-shoot?

‡ This is the crepitus lupi, or common fuz-ball, and said to be a powerful styptic.

especially of alder, and sometimes upon ash. It has a strange property, for in warm water it swells and opens extremely. It is of a dusky-brown colour, and used in the quinsy and inflammations of the throat; whence it seems to have a mollifying virtue.*

There is also a kind of spongy excrescence, growing chiefly upon the roots of the laser-tree, and sometimes upon cedars, &c. It is very white, light, and friable; we call it agaric, and it is famous in physic for purging viscid phlegm. It is also an excellent opener of the liver; but offensive to the stomach and the taste, being first sweet and afterwards bitter.

We find no super-plant that is fairly formed and figured, except misseltoe: as to which we have an idle tradition of a bird, called a missel-bird, that feeds upon a seed she cannot digest, and so expels it whole with her excrement, which falling upon the bough of a tree, produces the misseltoe. But this is a fable, it being not probable that birds should feed upon what they cannot digest. Besides, misseltoe is found but upon certain trees that bears no fruit to allure that bird, which feeding upon the misseltoe-berries,

* It has also a particular faintish odour when boiled, and then somewhat resembles a piece of black, well-dressed, supple leather.

and therefore being often found there, may have given occasion to the tale. But what ends the dispute is, that misseltoe has been found under the boughs, and not only above them, so that it cannot proceed from any thing that falls upon the boughs. It chiefly grows upon crab-trees, apple-trees, sometimes upon hazels, and rarely upon oaks,* the misseltoe whereof is accounted very medicinal.† It is an evergreen that bears a white glittering berry, and differs entirely from the tree whereon it grows. Two things therefore may be hence collected: first, that superfœtation proceeds from plenty of sap in the bough; secondly, that the sap must be such as the tree discharges, and cannot assimilate, else it would go into a bough; and besides, it seems more fat and unctuous than the ordinary sap of the tree, both by the berry, which is clammy, and because it continues green, winter and summer, which the tree does not.‡

This observation upon misseltoe may give

* Its growth upon the oak has been questioned. I once saw it in considerable plenty, growing upon a very young oak, which, for the curiosity, was sold at an extraordinary price to an apothecary of London.

† What certainty is there in the relation of its being specific in the epilepsy?

‡ For a farther account of misseltoe, see the Philosophical Transactions, No. 251, &c.

some light to other practices. Trial therefore should be made, by ripping the bough of a crab-tree in the bark, and watering the incision every day with warm dung-water, to see if it will produce misseltoe, or any thing like it; but it were yet more promising to try it with other watering and anointing less natural to the tree, as oil, beer, yeast, &c. provided they be such as do not kill the bough.

It were proper to try how plants would grow, if prevented from shooting their natural boughs. Poll a tree therefore, and cover it thick with clay on the top, and mark the event. I suppose it will put forth in roots; for so a cion will being turned down into clay. Therefore, in this experiment also, the tree should be closed with somewhat not so natural to it as clay. Try leather, cloth, or painting, provided they be not hurtful to the tree. It is certain that a brake has grown out of a pollard.*

The prickles of trees seem to be a kind of excrescences, for they will never become boughs, nor bear leaves. The vegetables that have prickles are the black and white thorn, the briar, the rose, the crab-tree, the goosberry, the barberry; these have it in the bough. The plants that have prickles in the leaf are holly, juniper,

* The manner wherein, should be examined.

whin, thistle; nettles also have a small venomous prickle, as borage has a harmless one. The cause seems to be hasty shooting, want of moisture, and closeness of bark; for the haste of the spirit to put forth a bough, the want of nourishment for the purpose, and the closeness of the bark, produces prickles in boughs; whence they are always pyramidal, the moisture spending itself after a little shooting. Prickles in leaves come also from putting more juice into the leaf than can spread smooth therein; and therefore the leaves are otherwise rough, as in borage and nettles. The leaves of holly are smooth, yet never plain, but, as it were, folded, for the same reason.

There are also plants which, though they have no prickles, yet have a kind of downy or velvet covering upon their leaves, as rose-campion, stocks, coltsfoot, &c. which down or nap proceeds from a subtile spirit in a soft or fat substance; for both stock-july-flowers, and rose-campion, stamped, have been successfully applied to the wrists in tertian or quartan agues; and the vapour of colts-foot is healing to the lungs, as the leaf also is healing in chirurgery.

Another kind of excrescence is an exudation of plants joined with putrefaction, as in oak-apples, which are found chiefly upon the leaves of oaks and willows. The country-people have

a kind of prediction, that if the oak-apple, when broken, be full of worms, it is a sign of a pestilential year, which seems probable, because they proceed from corruption. There is also, upon brier, a fine tuft or bush of moss differently coloured, which, if cut, is always found full of little white worms.*

SECT. XI.

OF THE PRODUCTION OF PERFECT PLANTS WITHOUT SEEDS.

EARTH taken from the bottom of vaults, houses, and wells, and put into pots, will afford various kinds of herbs, but some time is required for the germination. If taken from a fathom deep, it will put forth the first year; if much deeper, not till a year or two after. The nature of plants growing in the earth so taken up, follows the nature of the mould; if the mould be soft and fine, it producs soft herbs, as grass, plaintain, &c. and if harder and coarser, herbs more rough, as thistles, furz, &c. It is common

* Pursuant to the design, all the other excrescences of vegetables should be here enumerated, even those discovered by the microscope. See Dr. Hook's Micographia.

experience, that in alleys close gravelled, the earth brings forth; the first year, knot-grass, and afterward spire-grass; for the hard gravel or pebble, at the first laying, will not suffer the grass to come upright, but turns it to find its way where it can; but when the earth is somewhat loosened at the top, the ordinary grass comes up. And it is reported, that earth, taken at some depth out of shady and damp woods, and potted, will produce herbs of a fat and juicy substance, as pennywort, purslane, housleek, pennyroyal, &c.

Water also yields plants that have no roots fixed to the bottom; but these are less perfect plants, being chiefly leaves, and small ones, such as duck-weed, which has a leaf no bigger than thyme, but of a fresher green, and shoots a little string into the water far from the bottom. The water-lily has its root in the ground; so have many other herbs that grow in ponds.

It is reported likewise, that some plants grow upon the top of the sea, being supposed to proceed from a certain concretion of slime in the water, when the sun beats hot, and the sea stirs little. As for sea-weed and sea-thistle, they both have roots, but the sea-weed under the water, and the sea-thistle upon the shore.

The ancients have noted, that some herbs grow out of snow, laid up close together and putrefied,

and that they are all bitter: they name one, in particular, flomus, which we call moth-mullein. And worms are frequently found in snow, like earth-worms; whence possibly it may likewise yield plants.

The ancients also affirm, that some herbs grow out of stone; which may be, for toads have been found in the middle of freestone. We also see, that flints lying above ground gather moss; and some flowers grow upon walls, but whether upon the main brick or stone, or whether out of the lime or chinks, is not well observed; for alders and ashes have been seen growing out of steeples, though manifestly from the clefts, insomuch that when they grow large, they will disjoin the stones. There are likewise rock-herbs, but I suppose only where there is some mould or earth. It has likewise been found that great trees, growing upon quarries, have shot down their root into the stone.

It is reported, that in some mines of Germany there grow vegetables at the bottom; and the workmen say they have a magical virtue, and will not suffer them to be gathered.

The sea-sand seldom bears plants, because the sun exhales the moisture before it can incorporate with the earth, and yield a nourishment for plants. It is also affirmed, that sand has its root

in clay, and that there are no veins of sand any great depth within the earth.*

SECT. XII.

OF EXOTIC PLANTS.

It is reported, that earth brought from the Indies, and other remote countries, by way of ballast, being thrown upon some ground in Italy, produced foreign herbs unknown to us in Europe; and that from their roots, barks, and seeds bruised together, mixed with earth, and well watered with warm water, there came forth herbs much like the other.

Plants brought out of hot countries endeavour to put forth at the same time they usually do in their own climate: therefore, to preserve them,

* None of the instances here produced make expressly for the title, viz. the production of perfect plants without seed; but only for their production without the seed being sown by men. But there are many ways of sowing seed, by the means of birds, beasts, winds, the spontaneous bursting of flowers, &c. all which deserve to be enumerated. And perhaps it will at length be found, that every species of vegetables, even mushrooms have their seed, and are propagated by means thereof. See the account of mushrooms in the French Memoirs.

there is no more required than to keep them from being put back by cold. It is also reported, that grain transplanted from a hot country to a colder, will be more forward than the ordinary grain of the cold country. This may succeed better in grain than in trees, because grain is but annual, and so the virtue of the seed is not worn out; whereas a tree is debased by the ground whereto it is removed.

Many plants which grow in the hotter countries, will, if sown of seed, late in the spring, come up and endure most part of the summer, as we find in oranges, lemons, &c. the seed whereof, sown at the end of April, yields excellent sallads, mixed with other herbs. And I conceive that the seeds of clove, pepper, &c. if they could be had green enough to be sown, would do the like.*

* This article of exotics remains very deficient. In order to supply it, consult the botanical papers of the Philosophical Transactions, French Memoirs, and German Ephemerides.

SECT. XIII.

OF THE SEASONS OF PLANTS.

Some flowers, blossoms, grains, and fruits come early, and others late in the year. The early flowers with us are primroses, violets, anemonies, water-daffadils, the crocus vernus, and some tulips. These are all cold plants, which therefore seem to have a quicker perception of the heat of the sun than hot herbs have, as a cold hand sooner perceives a little warmth than a hot one. Those that come next in order are wall-flowers, cowslips, hyacinths, rosemary-flowers, &c. then pinks, roses, the flower-deluce, &c. The latest are July-flowers, holly-oaks, larksfoot, &c.

The earliest blossoms are those of the peach, almond, cornelian, mezereon, &c. being of such trees as have much moisture, either watery or oily. Whence the crocus vernus also, an herb that has an oily juice, puts forth early, for these likewise find the sun sooner than the drier trees.

Of the grains, the first are rye and wheat; the next oats and barley; then peas and beans; for though green peas and beans are eaten sooner, yet the dry ones used for horses are ripe last, and it seems that the fatter grain comes first.

The earliest fruits are strawberries, cherries, gooseberries, currans, certain apples, pears, apricots, rasberries; and after these, damascenes, most kinds of plumbs, peaches, &c. the latest are winter-apples, wardens, grapes, nuts, quinces, almonds, sloes, briar-berries, hips, medlars, services, cornelians, &c.

Commonly trees that ripen latest blossom soonest, as peaches, sloes, almonds, &c. and it seems a work of Providence, that they blossom so soon, as they could not otherwise have the sun long enough to ripen.*

Some fruits come twice a-year, as certain pears,† strawberries, &c. and they seem such as abound with nourishment; whence, after one period, before the sun grows too weak, they can endure another. The violet also, among flowers, comes twice a year, especially the double-white, and this is also a plant full of moisture. Roses also come twice, but not without cutting.

In Muscovy, though the corn come not up till late spring, yet their harvest is as early as ours, because the strength of the ground is kept in by the snow; and with us, if it be a long winter, it is commonly a plentiful year. After such winters likewise, the flowers and corn, both earlier

* Let the contradictory instances be sought.

† The Windsor pear, for instance.

and later, come commonly at the same time, which often proves troublesome to the husbandman. Sometimes red-roses and damask-roses come together. So likewise the harvest of wheat and barley. But this always happens, because the earlier stays for the later, and not that the later comes sooner.

Many fruit-trees, in hot countries, bear blossoms, young fruit, and ripe fruit, almost all the year successively.* And it is said, the orange and the fig do the like with us for a great part of summer. And no doubt this is the natural motion of plants; but either wanting juice to spend, or meeting with the cold of the winter, this circle of ripening cannot take place but in succulent plants and hot countries.†

Some herbs are annual, and die, root and all, once a year, as borage, lettuce, cucumbers, muskmelons, basil, tobacco, mustard, and all kinds of corn. Some continue many years, as hyssop, germander, lavender, fennel, &c. There are two causes of this dying: the first is, the tenderness and weakness of the seed, which makes the

* Particularly in Bermudas.

† How near can art approach this natural advantage of climate? Let a proper thermometer be contrived to regulate the heat of a green-house; and let the natural reciprocation of warmth, coolness, moisture, and fresh air, be imitated to exactness.

period in a small time, as in borrage, lettuce, cucumbers, corn, &c. and therefore none of these are hot. The other is, because some herbs can less endure cold, as basil, tobacco, mustard-seed, all which have much heat.

SECT. XIV.

OF THE DURATION OF HERBS AND TREES.

VEGETABLES of the largest body are most durable, as oak, elm, chesnut, &c. This holds in trees, but in herbs it is often otherwise; for borage, colewort, and pompions, which are herbs of the largest size, are of small duration; whereas hyssop, winter savoury, germander, thyme, and sage will last long. The reason is, because trees last according to the strength and quantity of their sap, being well defended by their bark against the injuries of the air; but herbs draw a weak juice, and have a soft stalk, and therefore those among them that last longest have a strong smell and a woody stalk.

Trees that bear mast and nuts are commonly more lasting than such as bear fruits, especially the moister fruits; thus the oak, beech, chesnut, walnut, almond, pine, &c. last longer than the apple-tree, the pear-tree, &c. because of the fat-

ness and oiliness of the sap, which always wastes less than the more watery.

Trees that put forth their leaves late, and also shed them late in the year are more durable than such as sprout early or shed betimes; for the coming late shews a moisture more fixed, the other more loose, and easier resolved. For the same reason, wild trees last longer than garden-trees; and of the same kind, such as have acid fruit, longer than such as have a sweet one.

Nothing makes trees, bushes, and herbs more durable than frequent cutting: this always causes a renovation of the sap, which now neither goes so far nor rises so faintly as when the plant is not cut; insomuch that annual plants, if seasonably cut, and suffered to come up still young, will last more years than one, as lettuce, purslane, cucumber, and the like. And for great trees, nearly all overgrown ones in church-yards, or adjacent to ancient buildings, or pollards, or dottards, and not at their full height.*

Experiment should be made to render plants more lasting than their ordinary period, as to make a stalk of wheat, &c. last a whole year, so as that the winter may not kill it; for we speak

* On this depends the advantage of pruning, which, if skilfully performed, always adds new life and vigour to the tree.

only of prolonging the natural period. I conceive, that whatever makes an herb come later than at its time will make it last longer. It were proper to try this in a stalk of wheat, set in the shade, and encompassed with a case of wood, not touching the straw, to keep out the open air.*

SECT. XV.

OF THE DIFFERENT FIGURES OF PLANTS.

TREES and herbs keep no order, and are not figured in the growth of their boughs and branches, because the sap being restrained in the bark, breaks not forth in the bodies of trees and stalks of herbs till they begin to branch; and when they make an eruption, they do it casually, where they find best way in the bark.† It is true, some trees are more scattered in their boughs, as the sallow, warden, quince, &c. some more pyramidal, as the pear, orange, fir, service, lime, &c. some more broad, as the beech, hornbeam, &c. and the rest are more indifferent.—The cause of scattering the boughs is the hasty

* Consult, upon this whole article, Mr. Evelyn's Sylva.

† See Dr. Sharrock's History of the Propagation and Improvement of Vegetables, page 142.

breaking forth of the sap, whence such trees rise not in a body of any height, but branch near the ground. The cause of the pyramidal form is the keeping in of the sap long before it branch, and the spending of it, when it begins to branch, by equal degrees. The spreading is caused by the rising of the sap plentifully without expense, and then putting forth speedily at once.

There are many herbs, but no trees, that seem to observe some order in putting forth their leaves, as having joints, knuckles, or stops in their germination, as July-flowers, pinks, fennel, corn, reeds, and canes. The cause whereof is, that the sap ascending unequally, tires and stops by the way. And it seems they have some closeness and hardness in the stalk, which hinders the sap from growing up, till it has gathered into a knot, and so is more urged to put forth; and hence they are most of them hollow when the stalk is dry, as in fennel, stubble, and canes.

All flowers have exquisite figures, and the flower-numbers are chiefly five and four. Primroses, briar-roses, single musk-roses, single pinks, July-flowers, &c. have five leaves; lilies, the flower-deluce, borage, bugloss, &c. have four leaves. But some have numerous leaves, though small, as marygolds, trefoil, &c. The sockets and supporters of flowers are figured, as in the five brethren of the rose, the sockets of July-

flowers, &c. All leaves also are figured, some round, some long, none square, and many jagged on the sides, which seldom holds in the leaves of flowers: for the jaggedness of pinks and July-flowers seems like the inequality of the oak or vine-leaves, but they seldom or never have any small pearls.*

SECT. XVI.

OF THE PRINCIPAL DIFFERENCES IN PLANTS.

SOME few plants bear blossoms before they have leaves, as almonds, peaches, cornelians, black-thorn, &c. but most have some leaves before they blossom, as apples, pears, plumbs, cherries, &c. The cause is, that those which yield their blossoms first have either an acute or sharp spirit, whence they commonly put forth early in the spring, and ripen very late; or else have an oily juice, which is apter to put out flowers than leaves.

Some plants are green all winter, others cast their leaves. The evergreens are holly, ivy, box, fir, yew, cypress, juniper, bays, rosemary, &c.

* Consult Mr. Ray, M. Tournefort, and the philosophical botanists, upon this article.

The cause of their holding green is the close and compact substance of their leaves and the pedicles of them. And the cause of this again is either the viscous juice of the plant, or its strength and heat. Of the first sort is holly, which is of so viscous a juice as to make bird-lime. The stalk of ivy is tough, and not brittle. Fir yields pitch; box is a close and heavy wood; and yew is a strong and tough wood. Of the second sort is juniper, which is an odoriferous wood, and makes a fierce fire. Bays likewise is a hot and aromatic wood, so is rosemary, for a shrub. The density of the leaves appears hence, that they are smooth and shining, as in bays, holly, ivy, box, &c. or hard and spiry. Trial should be made of grafting rosemary, bays, and box upon a holly-stock, because these are plants that grow all the winter. It were proper to try it also with grafts of other trees, either fruit-trees or wild ones, to see whether they will not yield fruit or bear leaves later and longer in the winter, because the sap of holly puts forth most in the winter. Perhaps also a mezereon-tree grafted upon a holly will prove both an earlier and larger tree.

Some plants have no flower, and yet bear fruit; some bear flowers, but no fruit; and some again bear neither flowers nor fruit.—Most of the great timber-trees, as oak, beech,

&c. bear no apparent flowers; some few fruit-trees, as the mulberry, walnut, &c. and some shrubs, as juniper, holly, &c. bear no flowers. Divers herbs also have seeds for their fruit, yet bear no flowers, as purslane, &c. Those that bear flowers and no fruit are few, as the double cherry, the sallow, &c. But for the cherry, it is doubtful whether it be not by art; and if so, then trial should be made whether apple, and other fruit-trees that blossom, may not be doubled. There are some few that neither bear fruit nor flower, as the elm, poplar, box, &c.

Most plants shoot still upwards, and support themselves, whilst others creep along the ground, or wind about other trees or props, unable to support themselves, as the vine, ivy, briar, bryony, woodbine, hop, &c. The cause is, that all plants naturally move upwards; but if the sap rise too fast, it makes a slender stalk, which will not support the weight, whence the latter sort are all hasty growers.*

* Many curious observations, for the improvement of this article, are supplied by the French Memoirs.

SECT. XVII.

OF COMPOSTS AND HELPS FOR GROUND.

THE first and most ordinary help for ground is stercoration. Sheep's dung is one of the best, the next is the dung of kine, and thirdly, that of horses, which is held somewhat too hot unless it be mixed. That of pigeons for a garden, or a small piece of ground, is excellent. The way of applying the dung to arable land is to spread it immediately before ploughing, so as to plough it in; for if spread long before, the sun will draw out much of its fatness. For grazing ground, the way is to spread it somewhat late, towards winter, that the sun may have less power to dry it up.

The second kind of compost is, divers kinds of earth, as 1. Marle, 2. sea-sand, 3. chalk, 4. earth upon earth, 5. pond-earth, and 6. mixtures of them. 1. Marle is thought the best, as having most fatness, and not heating the ground too much.* 2. The next is sea-sand, which obtains a particular virtue from the salt, for salt is

* See Sir Hugh Plat's Jewel-house of Art and Nature, page 114, &c.

the first rudiment of life.* 3. Chalk overheats the ground a little, and therefore does best upon cold clay or moist grounds. It is a common error, to think chalk helps arable, but not grazing ground. The error proceeds hence, that after chalking of the ground, they wear it out by many crops without rest, and then indeed it will afterwards bear little grass. It were a good experiment to lay chalk upon arable ground a little before ploughing, and to plough it in as they do dung; but then it must first be made friable by rain or lying. 4. Earth is a compost to earth. I knew a great garden that had a field, as it were, poured upon it, and it bore fruit excellently the first year; for the surface of the earth is always the most fruitful. And earth so prepared has a double surface. But such earth as affords saltpetre, if procurable without too much charge, is best. The way to hasten the growth of saltpetre is to exclude the sun, and prevent the growth of vegetables; and therefore to make a large thatched hovel over some quantity of ground, or even to plank the ground over, will produce saltpetre. 5. Pond earth or river earth is a very good compost, especially if the pond have been long uncleaned, and so the water be

* See Boerhaave's Chemistry, under the Processes upon Sea-salt.

not too hungry; and I judge it will be yet better if mixed with chalk.

The third help for ground is procured by means of some other substances, tho' not merely earthy, having a virtue to fertilize; wherein ashes excel; insomuch that the countries about Ætna and Vesuvius have a kind of amends made them, in the exceeding fertility of the soil, for the mischief done them by the eruptions, which fertility is caused by the ashes scattered over the ground. Soot also, though thin, spread in a field or garden, is found a very good compost. Salt is too costly: it has been tried, that mixed with seed-corn, and sown together, it proves serviceable; and I am of opinion, that powdered chalk, mixed with seed-corn, would do good, perhaps as much as chalking the ground all over. As to the steeping of seeds in several mixtures with water, to give them vigour, and watering grounds with compost water, we have spoke thereto already.*

The fourth help is suffering vegetables to die into, and so fatten the ground, as the stubble of corn, especially of pease. Brakes cast upon the ground in the beginning of winter, will make it very fruitful. It were proper also to try whe-

* See above, Sect. I.

ther leaves swept together, and mixed with some chalk and dung, to give them more heart, would not make a good compost; for there is nothing wasted so much as the leaves of trees, and as they lie scattered, and without mixture, they rather make the ground sour than otherwise.*

The fifth help for ground is heat and warmth. It has been anciently practised to burn heath, ling, and sedge, with the advantage of the wind, upon the ground. We find that the warmth of walls and enclosures is an amendment; so is lying open to the south; and the folding of sheep, as well by their warmth as their compost; and perhaps the covering of ground with brakes in the beginning of the winter may help by means of the warmth. Nay, some suspect, that the usual way of gathering flints in flinty ground, and laying them on heaps, is no good husbandry, because they would keep the ground warm.

The sixth help for ground is watering, which may be done two ways: the one by letting in and shutting out the water at seasonable times; for water let in at some times, if it stay not too long, does good, but at others, and if it stay too long, hurt: and this serves only for meadows

* Has the experiment of converting leaves into manure been fully tried?

adjacent to a river. The other way is, to bring water from some high grounds, where there are springs, into the lower, carrying it in long furrows, and from these furrows drawing it transverse, to spread the water; which makes an excellent improvement both for corn and grass; though the expedient proves the richer if these hanging grounds be fruitful, because the water thus washes down some of the fatness of the earth. Generally where there are great overflows in fens, or the like, the drowning of them in winter makes the following summer more fruitful, as keeping the ground warm, and nourishing it. But the fen-men hold, that the sewers may be kept so as to continue the water too long in the spring, till the weeds and sedge be grown up, because then the ground, like a wood, will keep out the sun, and so continue the wet, and never graze well that year.*

* Let the other kinds of amendment be here enumerated. See Mr. Evelyn's Terra, and the Philosophical Transactions. See also Sir Hugh Plat's Jewel-house of Art and Nature.

SECT. XVIII.

OF THE RELATIONS BETWEEN PLANTS AND INANIMATE BODIES.

ALL bodies have spirits and pneumatical parts; but the principal differences between animate and inanimate bodies are two. The first, that the spirits of animated things are all contained within themselves, and branched in veins and secret canals as the blood is; and in living creatures, the spirits have not only branches, but certain cells or seats, where the principal spirits reside, and whereto the rest resort; but the spirits in things inanimate are shut up, and cut off by the tangible parts, and are impervious one to another, as air in snow. The second grand difference is, that the spirits of animate bodies are in some degree kindled, or have a fine commixture of flame, and an aerial substance; but inanimate bodies have not their spirits inflamed or kindled. And this difference consists not in the heat or coolness of the spirits; for naptha, cloves, and other spices, have exceeding hot spirits, much hotter than oil, wax, &c. but are not inflamed. And when any of these weak and temperate bodies come to be inflamed, they gather a much greater heat than

others uninflamed, besides their light and motion.*

The secondary differences proceeding from these two radical ones, are, first, that plants are figured and determinate, which inanimate bodies are not; for as far as the spirit is able to spread and continue itself, so far goes the figure, and is then determined. Secondly, plants are nourished, but inanimate bodies are not; the latter have an accretion, but no alimentation. Thirdly, plants have a period of life, which inanimate bodies have not. And, fourthly, they have a succession and propagation of their kind, which inanimate bodies have not.

The differences between plants and fossils, besides those already mentioned, are these: 1. metals are more durable than plants; 2. more solid and hard; they are wholly subterraneous, whereas plants are part above ground and part below. Few creatures participate both of the nature of plants and metals. Coral is one of the nearest, and another is vitriol, which is aptest to sprout with moisture.

There is another particular affinity between plants and mouldiness, or putrefaction; for all putrefaction, if not dissolved in arefaction, will

* See more to this purpose in the author's history of Life and Death.

determine into plants or living creatures, bred by putrefaction: moss, mushrooms, agaric, &c. appear to be but the mouldiness of the ground, walls, trees, and the like. Flesh, fish, plants, and many other things, after mouldiness or corruption, produce worms. These putrefactions, notwithstanding their affinity to plants, have this difference from them, that they are without succession or propagation, though they are nourished, have a period of life, and likewise some figure. A cut citron, being left in a close room, for three summer months, there was grown out of the pith tufts of hair an inch long, with little black heads, as if they would have been some herb.*

SECT. XIX.

OF THE RELATION BETWEEN PLANTS AND ANIMALS.

THE affinities and differences between plants and animals are these: they have both of them spirits continued, branched, and inflamed. But,

* Here seems to be a considerable foundation laid for the natural history of mouldiness, which the microscope shews to be a kind of wood, or grove of plants. But this requires to be prosecuted in fruits, fermented liquors, and all vegetable, animal, and many mineral subjects.

1. in living creatures, the spirits have a cell, or seat, which plants have not. And, 2. the spirits of living creatures hold more flame than the spirits of plants. And these two are the radical differences.* The secondary differences are as follow: 1. plants are fixed to the earth, whereas animals are severed from it. 2. Animals have local motion, which plants have not. 3. Animals are nourished from their upper parts, the mouth chiefly, but plants from below. 4. Plants have their seed and seminal parts uppermost, animals lowermost; whence it was philosophically said, that man is like an inverted plant, for the root in plants is as the head in animals. 5. Animals have a more exact figure than plants. 6. They have a greater diversity of organs within their bodies and internal figures than plants. 7. They have sense, which plants have not. 8. They have voluntary motion, which plants have not.

The different sexes in plants are often distinguished by name, as male-piony, female-piony, male-rosemary, female-rosemary, he-holly, she-holly, &c. but generation by copulation extends

* This may deserve a very strict examination. See the author's history of Life and Death; and compare the doctrine there delivered to this purpose, with Mr. Boyle's experiments upon flame and air.

not to vegetables. But perhaps a binary of stronger and weaker, like masculine and feminine, holds in all living bodies, though it is sometimes confounded, as in creatures bred of putrefaction, where no marks of distinction appear; and it is sometimes doubled, as in hermaphrodites; but generally there are degrees of strength in all species. The intermediates between plants and animals are chiefly fixed, and have no local motion of removal, though they have motion in their parts, as oysters, cockles, and the like.*

SECT. XX.

MISCELLANEOUS EXPERIMENTS AND OBSERVATIONS UPON THE SUBJECT.

SCARCE any vegetables have branches without leaves, except coral. But in the desarts of S. Macario, in Egypt, is a long, leafless, brown plant, and branched like coral, only closing at the top, which, being set in water within doors, spreads and displays strangely. The natives have a superstitious belief that it helps delivery.

The Indian fig bows its branches down so low

* There are several particulars relating to this subject collected together in Boerhaave's Chemistry.

in one year as to take root again, and thus multiplies from root to root, making a kind of wood. This may proceed from the plenty of the sap and the softness of the stalk, which makes the bough, being overladen, and not strongly upheld, weigh down. Its leaves are as broad as a little target, but the fruit no bigger than beans; for the continual shade encreases the leaves, but stints the fruit, which nevertheless is of a pleasant taste: and this proceeds from the suppleness and gentleness of the juice of the plant, which also makes the boughs flexible.

Perhaps in some plants the sap rises so fast as to have no leisure to divide into many leaves, or put forth much stalk to the fruit. With us trees generally have small leaves in comparison. The fig-tree has the largest, and next to that the vine, mulberry, and sycamore; the least are those of the willow, birch, and thorn. But there are plants with far greater leaves than any tree, as the bur, gourd, cucumber, colewort, &c. The cause is, the hasty and plentiful rising of the sap.

There are three things in use for sweetness, sugar, honey, and manna. Sugar was scarce known to the ancients, and little used.* It is found in caves. Honey is made or gathered by

* See the article *Sugar*.

the bee; but I have heard that the labour of the bee is about the wax, and that in the beginning of May, honey-combs have been found empty of honey, and within a fortnight, when the sweet dews fall, filled like a cellar. It is probable that the sap and tears of some trees are sweet.* Perhaps also some sweet juices, fit for many uses, may be boiled out of fruits, to the thickness of honey or sugar. Let the means be enquired into. The likeliest matters are raisins, figs, currans, &c.†

Some plants are used for raiment, as hemp, flax, cotton, nettles, and growing silk: they also make cables of the bark of the lime-tree: it is the stalk that commonly makes the matter of the thread, and sometimes the down that grows a-top.‡

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* As the birch, the sycamore, &c. See the Philosophical Transactions.

† To these may be added malted corn, nuts, pulse, and every other vegetable capable of being malted. What is the best way of reducing the sweet substance of these commodities to an actual sugar? Let the common method of making sugar from the raw juice be tried. See the article *Sugar*. Consider of plantations of hips, parsnips, fennel, maple, and any other cheap vegetable that yields a saccharine juice.

‡ All the vegetables should be enumerated that will bear the hatchet.

Some plants have a mossy or downy root, and some have a number of threads like beards, as mandrakes, whereof impostors make an ugly image, giving it a face at the top, and leaving these strings to make a broad beard down to the foot. There is also a kind of nard in Crete, having a hairy root. So that there are bulbous roots, fibrous roots, and hairy roots. In the bulbous, perhaps the sap hastens most to the air and sun; but in the fibrous, delights more in the earth; the hairy being a middle nature between both, that besides shooting both upwards and downwards, puts forth in a round.

Some tears of trees are combed from the beards of goats; for when the goats bite and crop, especially in the morning dews, the tear comes out and hangs upon their beards. Of this sort is a kind of labdanum.

In order to remove foreign roots to a great distance, let them be close packed in earthen vessels. But if the vessels be not very large, make some holes in the bottom, to give refreshment to the roots, which otherwise will decay and suffocate.

The ancient cinnamon was, of all plants, while it grew, the dryest:* and the things known

* The great apparent dryness of the common cinnamon has perhaps given occasion to suspect that this fine aroma-

to comfort other plants made this more steril, for in showers it prospered worst; it also grew among bushes of other kinds, where plants do not commonly thrive, neither did it love the sun. There might be one cause of all these effects, viz. the sparing nourishment it required. Quere, how far cassia, which is now the substitute for cinnamon, participates of these properties?*

There were anciently vines of much larger bodies than we are acquainted with; so that cups, and an image of Jupiter has been made of them. But perhaps these were wild vines; the vines used for wine being so often cut, dug, and dressed, that their sap goes into the grapes, whence the stalk cannot increase much in bulk.† The wood of vines is very durable, without rotting; and though no tree, while green, has such brittle twigs, yet the wood dried is extremely tough, and was used by the Roman captains for their cudgels.

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tic cannot, in England, be distilled, for its oil, to advantage. But those who are skilful in the drawing of essential oils, may find the contrary upon trial.

* Wherein did the ancient cinnamon differ from the modern? Cassia lignea differs considerably from the present cinnamon, particularly in abounding with a mucilaginous part, which cinnamon is without.

† Is there not also an essential difference betwixt the two species?

It is reported, that in some places vines are suffered to grow like herbs, spreading upon the ground, and that the grapes of those vines are very large. It were proper to try whether plants usually sustained by props, will not bear larger leaves and fruits, if laid along the ground, as hops, ivy, woodbine, &c.

It is credibly reported, that to lay good store of grape-stones about the root of a vine, will make the vine come earlier, and prosper better.* This may be tried with other kernels, laid about the root of a plant of the same kind, as figs, apples, &c. The cause may be, that the kernels attract the juices fit to nourish the tree, as these would be trees themselves, if there were no root; but the root, being of greater strength, draws the nourishment from them.

To preserve quinces, apples, &c. plunge them in honey; but because honey may give them an over-luscious taste, try sugar, or syrup of wine, boiled to a due height.† This should likewise

* Does it make the vine prosper better than any other manure?

† This syrup of wine, I conceive, is made by boiling wine to the consistence of a syrup, either with or without the addition of sugar. The remains, after the distillation of brandy, may be thus treated to advantage. But let the operation be performed in balneo mariæ, whereby an excellent preparation will be obtained, of service both in food and physic.

be tried in oranges, lemons, and pomegranates. The conservation of fruit should also be tried in vessels filled with fine sand, or powder of chalk, or in flower, the dust of oak-wood, &c.* Fruits intended for long keeping must be gathered before they are full ripe, and in a fair dry day, towards noon, the wind blowing not south, the moon being under the earth, and in her decrease.

If grapes be suspended in an empty vessel well stopped, and set in a dry place, it is said they will keep long; but better, it is thought, in a vessel half full of wine, provided the grapes do not touch the wine. It is reported, that preserving the stalk helps to preserve the grape, especially if some of the stalk be took off along with the branches, or the stalk be put into the pith of alder, the alder not touching the fruit.†

Some herbs and plants are good to eat raw, as lettuce, endive, purslane, cresses, cucumbers, radish, &c. others only after they are boiled, as

* These are serviceable methods of preserving either fruits or flowers.

† There are numerous expedients of this kind. The way in France is to hang the grapes in a dry room upon lines, so that no two bunches may touch; and thus they keep them long moist, and tolerably fresh. This method seems taken from that other of preserving them upon the vine, where they will hang long, if the vine be housed, or secured from the injuries of the weather.

parsley, clarey, asparagus, &c. but many herbs are not esculent at all, as wormwood, grass, centaury, hyssop, lavender, &c. The herbs that are not esculent want two properties wherein nourishment consists, viz. fatness and sweetness;* and have bitter and overstrong tastes, or a juice so crude as not to be ripened to the degree of nourishment. Herbs and plants that are esculent when raw, have a fatness or sweetness, such are onions, lettuce, &c. but it must be such a fatness as is not too gross and overloading to the stomach: for parsnips and leeks have fatness, but it is too gross and heavy without boiling. This fatness must also be in a substance somewhat tender; for wheat, barley, artichokes, &c. are no good nourishment, till they have passed the fire, which ripens and makes them soft, tender, and esculent. Radish, tarragon, and the like, are rather for sauce than nourishment. And some herbs, which are not esculent, are however potulent, as hops, broom, &c. Quere, what herbs are good for drink besides these two? for it may ease the charge of brewing, if they make beer require less malt, or render it more durable.†

* Let this be examined in the inductive method, to see if an axiom can be formed upon it.

† The brewers are said to use wormwood, gentian, &c.

The parts of plants fit to nourish the body are seeds, roots, and fruits, but chiefly seeds and roots. Leaves, flowers, and stalks yield little or no nourishment. The cause is, that roots, seeds, and fruits have more of the oily substance; and leaves, flowers, and stalks, more of the watery. Again, they are more concocted; for the root which always continues in the earth, is still concocted by the earth; and fruits and grains are half a year, or more, in concocting; whereas leaves are out and perfect in a month.*

Plants are usually stronger in their seed, both to the taste and smell, than in the leaf and root. The cause is, that in plants not of a fierce and eager spirit, the virtue is increased by concoction and maturation, which is always most in the seed; but in plants of a fierce and eager spirit, they are stronger whilst the spirit is inclosed in the root: and the spirits do but weaken and dissipate when they come to the air and sun, as we find in onions, garlic, dragon, &c. Nay, some plants have their roots very hot and aromatic, yet their seeds rather insipid, as ginger: the heat of those plants being very dissipable, which

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instead of hops; treacle instead of malt; and, to give an additional strength, grains of paradise.

* This matter requires a farther enquiry and verification.

under the earth is kept in; but exhales when it comes to the air.*

The juices of fruits are either watery or oily. Among the watery come all the fruits that afford potable liquors; as the grape, the apple, the pear, the cherry, &c. And there are some others, which, though not used for drink, yet appear of the same nature; as plumbs, services, mulberries, rasberries, oranges, lemons, &c. and those juices that are too fleshy to make drink by expression, may do it by the admixture of water.† Perhaps hips, and briar-berries would do the like.‡ The fruits that have oily juices, are

* See the Processes relating to Vegetables, in Boerhaave's Chemistry.

† Poculaq; admistis imitantur vitea sorbis.

‡ These are intimations of considerable service. All kinds of plumbs, though ever so hard and fleshy; being bruised and mixed with water, ferment kindly; and with skill make tolerable wines. Hips are an excellent fruit for this purpose; but blackberries make a coarse wine; though a good brandy. Certainly it were practicable to have plantations of such fruit-trees in England, as should afford us wines, equal in goodness to those of foreign growth. Some have tolerable success with the burgundy grape; some with the morelli cherry; some with the white curran; some with the white edar, &c. And, perhaps, by a proper expedient our better kinds of cyder are convertible into wines, not to be distinguished from the best wines of France or Portu-

olives, almonds, nuts, pine-apples, &c. and their juices are all inflammable.* Observe likewise, that some of the watery juices, after fermentation, will burn and flame; as wine. There is a third kind of fruit that is sweet, without either sharpness or oiliness: such as the fig, the date,† &c.

It has been noted, that most trees, especially those that bear mast, are fruitful but once in two years: the cause is, the expense of sap; for many orchard trees, well cultured, will bear several years together.‡

No tree bears so many bastard fruits as the oak: for besides the acorn, it bears galls, oak-apples, certain oak-nuts, which are inflammable; and certain oak-berries, sticking close to the body of the tree without stalk. It bears also misseltoe, though rarely.§ The cause of this may be, the closeness and solidity of the wood, and pith

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gal, whether red or white. See Mr. Austen's Treatise of Fruit-Trees, the Vinetum Britannicum, Boerhaave's Chemistry, &c.

* The plants that afford oil should be diligently sought after; on account of their great utility. Consider of beech-mast, the sun-flower-seed, mustard-seed, &c. for this purpose.

† These also should be enumerated; as being not only food, but capable of affording drink by fermentation

‡ Is this cause justly assigned?

§ See above, Sect. X.

of the oak; whence different juices make different eruptions. And therefore, to produce superplants, we must give the sap a plentiful rise, and a hard issue.*

There are swo excrescences of trees; both of them growing in the nature of mushrooms: the one the Romans called Boletus; which grows upon the roots of oaks, and was a dainty of their table; the other is medicinal, and called agarick, which grows upon the oak; and is also affirmed to grow at the root. I conceive that many excrescences of trees grow chiefly where the tree is dead, or faded: the sap there corrupting into some preternatural substance.†

Most trees bear best on the lower boughs; as oaks, figs, walnuts, pears, &c.‡ but some bear best on the top; as crabs, &c. Those that bear best below, are such as shade befriends; for generally fruit-trees bear best below: because the

* If the cause be just; so will the rule: and observe, in general, that the discovery of causes is the finding of rules. This has been intimated more than once already; but the importance of the thing may allow of a repetition.

† This subject is touched above: See Sect. X. See also more to the same purpose in the Philosophical Transactions, No. 330.

‡ This should seem to be meant of wall-trees, rather than standards.

sap has but a short way to go.* But shade hinders the lower boughs; except in such trees as delight in shade, or bear it well. Those therefore are either strong trees, as the oak; or have large leaves, as the walnut and fig; or else they grow pyramidal as the pear. But if they require much sun, they bear best on the top; as in crabs, apples, plumbs, &c.

Some trees bear best when they begin to be old; as almonds, pears, vines, and all the trees that yield mast. The cause is, that all trees bearing mast, have an oily fruit; and young trees a more watery juice, and less concocted: and of this kind is the almond. The pear likewise, though it be not oily, yet requires much sap, and well concocted; for it is a heavy and solid fruit; much more so than apples, plumbs, &c. The vine bears more grapes when it is young; but grapes that make the best wines, when it is old: the juice being then better concocted. And we see wine is inflammable; so that it has a kind of oiliness: but most trees bear best when young.

Some plants ouze out a milk when cut; as figs, sow-thistles, spurge, &c. The cause may be, a tendency to putrefaction: for these are all acrimonious; though one would expect them

* Is there not some more latent cause of the effect? see the French Memoirs, and Philosophical Transactions.

mild. If you write upon paper with the milk of the fig-tree, the letters will remain invisible till the paper be held to the fire, and then they grow brown; which shews the juice to be sharp or fretting.* Lettuce is thought poisonous, when so old as to have milk; spurge is a kind of poison in itself; and sow-thistles, though rabbits eat them, yet sheep and cattle will not: besides, the milk thereof rubbed upon warts, soon wears them away; which shews the milk to be corrosive. Wheat also, and other corn, if taken from the ground before they sprout, are full of milk; and the beginning of germination is always a kind of putrefaction.† Euphorbium also contains a milk, though not very white, but of a great acrimony; and celandine a yellow acrimonious milk, that cleanses the eyes, and is good in cataracts.‡

There is scarce a plant that yields a red juice in the blade or ear, except that which affords the Sanguis Draconis; and grows chiefly in the island Socotra. The herb Amaranthus, indeed, is red all over; and brasil is red in the wood: so is red sanders. The Sanguis Draconis tree

* On what principle is the consequence founded?

† Observe it particularly in malting, where the operation passes wholly under the eye.

‡ Compare this with the account given of vegetables in Boerhaave's Chemistry.

grows in the form of a sugar-loaf. Perhaps the sap of that plant concocts in the body of the tree. For grapes and pomegranates are red in the juice,* but green in the tear: and this makes the Sanguis Draconis tree less towards the top; because the juice does not rise quick; and is, besides, very astringent, and therefore of slow motion.

It is said, that sweet moss sometimes grows upon the poplar as well as the apple-tree; and yet the poplar-tree has a smooth bark, and little moss. The moss of the Larix tree, also burns sweet, and sparkless in the burning. Enquire about the mosses of odoriferous trees, as cedar, cypress, lignum-aloes, &c.

Hemlock is noted for procuring the least painful death; and therefore, out of humanity, was used at Athens, for executing capital offenders. The poison of the asp has some affinity with this plant. The cause is, that the torment of death being chiefly produced by the struggle of the spirits; the cold vapours of these quench the spirits by degrees; as in the death of an extreme old man. I conceive it less painful than opium; because opium has hot parts intermixed with it.†

* That is, upon pressure.

† Though the description given of the ancient hemlock by Dioscorides, may seem to agree with ours; perhaps the

Some fruits are sweet before they are ripe; as myrobalans, fennel-seed, &c. some never ripen to be sweet; as tamarinds, barberries, sloes, &c. The cause is, that the former have much subtile heat, which gives early sweetness; whilst the latter have a cold and acid juice, which no heat of the sun can sweeten. But the myrobalan has parts of contrary natures; being both sweet and astringent.*

Few herbs have a salt taste; but the blood of living creatures is saline. The cause may be hence, that salt, though the rudiment of life, yet the original taste does not remain in plants; for we have them bitter, sour, sweet, biting, but seldom salt: whilst, in animals, all those high tastes may happen to be in the humours, but seldom in the flesh, or substance; this being of a more oily nature, which is not very susceptible of such tastes. The saltness of blood is but a light and secret saltness: and even among plants, some participate of saltness; as sea-weed, samphire, scurvy-grass, &c. It is certain, that out of the

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two plants differ greatly in efficacy. It is said that several have eaten of our hemlock without any ill effect. What affinity has the Oenanthe Cicutæ facie with the ancient hemlock? see Wepfer upon the subject.

* Let a nearer approximation be made to the cause.

ashes of all plants a salt is extracted for medicinal use.*

Barley being steeped three days in water, then drained and turned upon a dry floor, will sprout half an inch long; and if let alone without turning, it will shoot much more, till the heart be out. Wheat does the same. Try it also with pease and beans.† This experiment should be driven farther: for it appears already, that the earth is not necessary to the first sprouting of plants; and rose-buds set in water will blow: therefore try whether the sprouts of such grains may not be raised to an herb, or flower, with water only, or some small commixture of earth; for if they may, it should seem they will grow much faster in water than in earth: the nourishment being easier drawn out of water, than out of earth. Try the same experiment with roots as well as grains: for example, steep a turnip a-while, then dry it, and see whether it will sprout.‡

* See the processes upon vegetables in Boerhaave's Chemistry.

† They do the same.

‡ Here is a noble direction given for the application of the first part of the common process of malting, to other vegetable subjects: and how far this experiment may be carried, and to what advantage, seems little apprehended. Is it not applicable to nuts, pulse, and roots, as well as to all sorts of grain, even rice, millet, &c. See, in the Philoso-

Malt in the drenching will swell, so as, after sprouting and drying upon the kiln, to gain at least a bushel in eight; yet the sprouts are rubbed off; and there will be a bushel of dust, besides the malt. This, I suppose, happens not only from the loose lying of the parts, but from some addition of substance, drawn from the water in which it was steeped.* Malt acquires a sweetness in the operation; as appears yet more in the wort. The edulcoration of things should be tried to the full; as tending to nourishment:† and the making of things inalimental, to become alimental, may be of great profit, in producing new kinds of provision.‡

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phical Transactions, a method of malting that hard and gummy substance, Indian Wheat, by suffering it first to sprout in the ground; then drying it upon the kiln. Lowth. Abridg. Vol. II. page 630,—634, or No. 142.

* Malsters have a trick of over-malting their barley, in order to make it measure well: but what additional weight can they give it? or does it naturally acquire any in the making?

† See above, Sect. 18.

‡ Here is a large field of enquiry opened, that reaches to the subjects both of the vegetable and animal kingdom. The making of malt and sugar may serve as capital instances of the kind, in vegetable matters; and, in animal ones, the method of converting solid bones into good nourishment, is an experiment by no means attended to as it deserves.

Most seeds in growing leave their husk, or rind about the root: but the onion carrys it up; whence it appears like a cap on the top of the young onion. The cause may be, that its skin, or husk, is not easy to break; as we see, in peeling of onions, the skin is a clinging substance.

Plants that have curled leaves, abound with moisture; which comes so fast on, that they cannot spread themselves plain, but must needs collect together. The weakest kind of curling is roughness; as in clary and burr: the second is curling on the sides; as in lettuce, and young cabbage: and the third is folding into an head; as in cabbage, full grown, and cabbage-lettuce.

It is said, that fir and pine, especially if old and putrefied, though they shine not, as some rotten woods do; yet, in sudden breaking, will sparkle like hard sugar.

Some roots of trees strike deep into the ground; as the oak, pine, fir, &c. some spread more towards the surface; as the ash, cypress, olive, &c. The cause of this may be, that such trees as love the sun, unwillingly descend far into the earth, and therefore commonly shoot up much; for, their desire of approach to the sun, makes them spread the less in their body. And the same reason, to avoid recess from the sun, makes them spread the more under ground. And we see that some trees, planted too deep in the ground

to approach the sun forsake their first root, and put out another nearer the surface of the earth. We see also, that the olive is full of an oily juice; the ash makes the best fire, and the cypress is a hot tree; but oak loves the earth, and therefore grows slowly. Pine, and fir likewise, have so much heat in themselves, that they the less require the sun. There are herbs also, that have the same difference: thus the Morsus Diaboli strikes its root down so low, that it cannot be plucked up without breaking.*

A branch of a tree being unbarked at the bottom, and so set in the ground, has grown; even in such branches as would not have grown if set with the bark on: and yet a tree pared round in the body above ground, will die. The cause may be, that the unbarked part draws the nourishment best; but the bark continues it only.†

The reed, or cane, is a succulent plant, that grows only in water: it is hollow; knuckled both stalk and root; and being dry, becomes more hard and brittle than other wood: it puts forth no boughs, though many stalks from one root. It differs greatly in size; the smallest be-

* Cannot a nearer approximation be here made to the cause?

† There are many considerations to this purpose in the French Memoirs.

ing fit for thatching houses, and stopping the chinks of ships better than glew, or pitch. The second size is used for angle-rods, and staves; and in China, for beating offenders upon the thighs. The different kinds of them are, the common reed, the Cassia Fistularis, and the sugar-cane.* Of all plants, it bows the easiest, and rises again. It seems, that of plants nourished with a mixture of earth and water, it draws most nourishment from water; which makes it the smoothest of all others in bark, and the hollowest in body.†

The sap of trees is of different natures: some more watery and clear, as that of the vine, birch, pear, &c. some thick, as that of the apple; some gummy, as the cherry: some frothy, as the elm; some milky, as the fig. In mulberries, the sap seems to rise chiefly towards the bark; for if the tree be cut a little into the bark, the sap will issue; but not if the tree be pierced deeper. The trees that have the moistest juices in their fruit, have commonly the moistest sap in their body: for vines and pears are very moist; but apples somewhat more spungy. The milk of the fig has the quality of rennet, to coagulate milk: so have

* Let the other species be enumerated.

† What certainty is there in this conjecture?

certain sour herbs, wherewith they make cheese in Lent.*

The timber and wood are, in some trees, more clean; and in others more knotty: and it is proper to try it, by speaking at one end, and laying the ear at the other: for if the tree be knotty, the voice will not pass well. Some have the veins more varied and chambletted; as oak, and maple; others more smooth; as fir, and wallnut: some more easily breed worms, and spiders: some more difficultly, as it is said of Irish trees. There are many other differences that concern their use: thus oak, cedar, and chestnut, are best for building. Some are best for plough-timber, as ash; some for piers, that are sometimes wet and sometimes dry, as elm; some for planchers, as deal; some for tables, cupboards, and desks, as wallnuts; some for ship-timber, as oaks that grow in moist grounds; for this makes the timber tough, and not apt to shiver with ordnance: wherein English and Irish timber are thought to excel: some for masts of ships, as fir and pine; because of their length, straitness,

* For an account of the different juices in different parts of the same, or different vegetables, see Boerhaave's Chemistry.

and lightness; some for paling, as oak; some for fewel, as ash: and so of the rest.*

The coming of trees and plants in certain regions, and not in others, is sometimes casual; for many trees have been transplanted, and prospered, well. Damask-roses have not been known in England above three hundred years; though now so common. But the thriving of plants in certain soils more than in others, is merely natural. The fir and the pine, love mountains; the poplar, willow, sallow, and alder, love rivers and moist places; the ash loves coppices, but is best in standards alone: juniper loves chalk; so do most fruit-trees: samphire grows only upon rocks; reeds and osiers, where they are washed with water: the vine, loves the sides of hills, to the south-east sun,† &c.

The growth of certain herbs discovers the nature of the ground where they grow: thus wild thyme shews a good feeding-ground for cattle; betony and strawberries, grounds fit for wood; camomile denotes a mellow ground, fit for wheat; mustard-seed, growing after the plough, shews a

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* Consult Mr. Evelyn's Sylva. See also the Acta Eruditorum, for the year 1708, page 163, &c.

† Could not the physical causes of these varieties be discovered by proper sets of experiments, that should manifest the particular nature of every species?

strong ground for wheat: burnet, a good meadow; and the like.*

Other plants, besides misseltoe, grow out of trees. In Syria there is an herb called Cassytas, which, growing out of a tall tree, winds itself about the tree; and sometimes about thorns: a kind of polypody grows out of trees, though it twines not: so does an herb called Faunos, upon the wild olive; and another, called Hippophæston, upon the fuller's-thorn; and is supposed good for the falling-sickness.†

It has been observed, that the cold easterly winds are prejudicial to fruit; and that south winds also are hurtful; especially in blooming-time; and the more, if followed by showers. It should seem, that they call forth the moisture too fast. West winds are the best. It has also been observed, that green and open winters prejudice trees; so that if two or three such winters come successively, almonds, and some other trees, will die. The cause is, the earth's exhausting itself too fast.

Snows lying long, cause a fruitful year: for, 1. they keep in the strength of the earth: 2. they

* All the just observations of this kind, should be carefully collected.

† Let all the instances of this kind be produced. See above, Sect. X.

water the earth better than rain; the earth sucking, as it were, the water out of the snow: and 3. the moisture of snow is the finest moisture; as being the froth of the water-clouds.*

Showers falling a little before the ripening of fruits, prove serviceable to all such as are succulent and moist; viz. vines, olives, pomegranates, &c. though this rather produces plenty than goodness; for the best wines are made in the driest vintages. Small showers are likewise good for corn, if parching heats come not upon them: generally night-showers are better than day-showers; because the sun follows not so fast upon them: and we find in watering by hand, that it is best, in summer time, to water in the evening.

The differences of earths should be diligently examined. The earth that easiest softens with showers is commended; yet some of that kind will be very dry and hard before rain. The earth that throws a great clod from the plough, is not so good as that which throws up a smaller. The earth that easily produces moss, and may be called mouldy, is not good. The earth that smells well upon the digging, or ploughing, is commended; as containing the juice of vegeta-

* Are there not other causes assignable for the effect? See Mr. Boyle's History of Cold.

bles almost ready prepared. Poorness of herbs shews poorness of earth; and especially if they be dark in colour: but if the herbs shew withered, or blasted at the top, it denotes the earth to be very cold; so does the mossiness of trees. Earth where the grass is soon parched with the sun, is commonly forced, and barren in its nature. The tender, chessom, and mellow earth, is the best; being mere mould, between the two extremes of clay and sand; especially if not loamy and binding. The earth that can scarce be ploughed after rain, is commonly fruitful; as being cleaving, and full of juices.*

It is strange that dust should make trees more fruitful, and particularly vines; upon which they purposely throw it. It should seem that this powdering, when a shower comes, makes a kind of soil to the tree; being earth and water finely laid on: and it is observed, that countries where the fields and ways are dusty, bear the best vines.

It is recommended, to lay the stalks and leaves of lupins about the roots of trees; or to plough them into the ground where corn is sowed. To burn the cuttings of vines, and cast

* This is an interesting subject, that requires a rigorous, philosophical, and chemical treatment. Let the analysis of different earths be made, by simple elixation, evaporation, &c. See Mr. Evelyn's Terra.

them upon land, is very good. And the ancients generally conceived, it was best to dung the ground when the west wind blew, in the decrease of the moon; the earth being then, perhaps, more thirsty and open, to receive the dung.*

The grafting of vines upon vines seems not now in use; though the ancients had it in three ways: the first was incision, which is the ordinary manner of grafting: the second was terebration through the middle of the stock, and putting the cion therein: and the third was, paring two vines, that grew together, to the marrow, and binding them close.†

The diseases and accidents of corn should be enquired into; though many of them, perhaps, are not to be remedied. 1. Mildew is one of the greatest, which proceeds from closeness of air; whence it seldom happens in hills, or large champaign ground. This cannot otherwise be remedied in countries of small enclosure, than by turning the grounds into larger fields: which I have known to succeed in some farms. 2. The shooting up of wild oats, into which corn, espe-

* Have the sensible effects of particular winds upon the ground been carefully observed? See the author's History of Wind; and Mr. Boyle's History of Cold.

† None of these ways are said to be effectual; but vines are easily raised from slips.

cially barley, is often said to degenerate.* This happens chiefly from the weakness of the grain sown; for if it be either too cold, or mouldy, it will bring forth wild oats. 3. The satiety of the ground; for if ground be still sown with the same corn, the crop will be poor: therefore, besides the giving rest to the ground, we must vary the seed. 4. The ill accidents proceeding from winds; which hurt, both at the flowering, by shaking off the flowers; and at the full ripening, by shaking out the corn. 5. Another ill accident is drought, at the spindling of the corn; which with us is rare; but in hot countries common; insomuch that the word calamitas was first derived from calamus; when the corn could not get out of the stalk. 6. Another is overwet at sowing-time; which, with us, breeds dearth; the corn in this case never coming up: and frequently they are forced to sow summer-corn again, where they sowed winter-corn. 7. Another bad accident is, where frosts continue without snow; especially in the beginning of the winter, when the seed is new sown. 8. Another disease is worms; which sometimes breed in the root, upon hot suns and showers, immediately

* But is there any assured instance of wheat, or barley, ever degenerating into oats?

after the sowing. And a worm breeds in the ear itself; especially when hot suns often break out of clouds. 9. Another disease is weeds; such as either choke or over-shadow the corn, and bear it down, or starve and deceive it of nourishment. 10. Another is rankness of the corn; which they remedy by mowing it after it is come up; or putting sheep into it. 11. Another is the laying of corn with great rains, near, or in harvest. 12. Another bad accident is, if the seed happen to have touched oil, or any fat thing, which has a contrariety with the nourishment of water.*

The remedies for the diseases of corn, are. 1. To steep the grain before sowing in wine, for a while. 2. To mix seed-corn with ashes. 3. To sow at the wane of the moon, is thought to make the corn sound. 4. It has not been practised, but thought of use, to make some mixture in corn; as to sow a few beans with wheat. 5. It has been observed, that to sow corn with houseleek is serviceable. 6. Though the grain that touches oil or fat, receives hurt; yet the steeping of it in the dregs of oil, when beginning

* The several diseases of corn should be sought and described, as fully and accurately in the natural history of vegetation, as the diseases of the body in the art of medicine.

to putrefy, which they call amurca, is thought to defend it against worms. 7. It is reported, that to mow corn makes the grain larger; but emptier, and more husky.*

Seed of a year old is found best; that of two or three years old bad; and that which is older, quite barren: though some seed and grains keep better than others. The corn which lies lowest in the vanning, is the best: and that which, when broken or bitten, retains a little yellowness, is better than that which is very white.

Of all the roots of herbs, that of sorrel is observed to strike the deepest; insomuch as to descend four foot into the earth: it is also the root that longest continues fit for setting again. It is a cold acid herb, that seems to love the earth, and is not much drawn by the sun.

Some herbs thrive best when watered with salt water; viz. radish, beet, rue, pennyroyal, &c. and this trial should be extended to some other herbs, especially those that are strong; as Tarragon, mustard, rocket, and the like.

It seems strange, that poisonous creatures

* Much accuracy, many judicious experiments, and an ample stock of close observations, seem requisite to give the necessary light of information in this matter; for forming axioms, and sure rules of practice. See the Philosophical Transactions; the French Memoirs; and the German Ephemerides, passim.

should affect strong-smelling, and wholesome herbs; as, that the snake should love fennel; the toad delight under sage; frogs under cinquefoil, &c. but, perhaps, it is rather the shade, or other coverture that they affect, than the virtue of the herb.

It would be very advantageous to discern of what corn, herbs, or fruits, there is likely to be a plenty, or scarcity, by certain signs and prognostics, at the beginning of the year: because such as would come in plenty, might be bargained for upon the ground; as it is related of Thales; who, to shew how easy it was for a philosopher to be rich, when he foresaw a great plenty of olives, made a monopoly of them. And for scarcity, men may make profit in keeping the old store. Long continuance of snow, is thought to make a fruitful year; and an early, or very late winter, a barren year for corn: an open and serene winter, an ill year of fruit. Other prognostics of the like nature, are diligently to be enquired after.*

Great profit may attend any considerable improvement in vegetation: and with this view we would recommend the following experiment.

* The sure way of obtaining this end, seems somewhat slow and laborious, as depending upon an exact meteorological history; which is not, perhaps, at present

See the author's History of Winds.

1. The making of composts of fallen leaves, river-mud, earth, and chalk.

2. The inclosing of earth, or sheltering it from the weather; to enrich it for manure, or the yielding of salt-petre.

3. The setting of wheat and pease, instead of sowing or scattering them with the hand.

4. The improvement of crops, by steeping the seed in proper saline liquors.

5. The early raising of pease, cherries, and strawberries.

6. The strengthening of earth; that it may yield frequent returns of radishes, parsnips, turnips, &c.

7. The increasing the roots of onions, carrots, radishes, and other of the esculent kind.

8. The sowing the seed of trefoil.

9. The planting of woad.

10. The planting of tobacco.

11. Grafting upon the boughs of old trees.

12. The quick raising of coppices.

13. The planting of osiers in wet ground.

14. The preserving of oranges, lemons, citrons, pomegranates, all the summer.

15. The sowing of fennel.

16. The multiplying and dressing of artichokes.

17. The fitting of hay, haws, hips, trefoil, bramble-berries, woodbine, wild thyme, &c. for

brewing, instead of malt; and the using of thistles for hops.*

And there are numerous particulars of the like kind.

Some plants seem to have singularities, or particulars different from all others: the olive has the oily part only on the out-side; whilst other fruits have it in the nut or kernel. The fir has, in effect, no stone, nut, or kernel; unless its little grains be accounted kernels. The pomegranate, and pine-apple, among other fruits, have only grains distinct in several cells. No herbs have curled leaves but cabbage, and cabbage-lettuce.† None have double leaves, one belonging to the stalk, another to the fruit or seed, but the artichoke. No flower has the same kind of spread as the woodbine. This is a large field of contemplation; for it shews, that, in the production of some species, there is frequently a composition of matter that may be greatly diversified; in others, a composition that happens rarely, and

* Here appear to be several useful hints proposed, and a much greater number intimated. If it were to the present purpose, we could offer several considerations, and a set of experiments, that might add light and confirmation to these thoughts. But that would carry us too far beyond the design of these notes; which is not to execute, but merely to indicate.

† Consult the botanists for others.

admits of little variety. So likewise, among beasts; dogs have a resemblance with wolves and foxes; horses with asses; hares with coneys, &c. So among birds; kites and kestrels have a resemblance to hawks; common doves to ring-doves and turtles; black-birds to thrushes; crows to ravens; daws to choughs, &c. But elephants, and swine, among beasts; the bird of paradise, and the peacock, among birds, and some few others, have scarce any other species like them.

We leave the description of plants and their virtues to Herbals, or the like books of natural history; wherein men have shewn great diligence, even to a degree of curiosity: for our experiments are only such as constantly tend to the discovery of causes, and the raising of axioms. Though we are not ignorant that some, both ancient and modern writers, have also endeavoured to tread this path: but, to say the truth, their causes and axioms, are full of imagination; and so infected with received and current theories, as, in reality, to corrupt experience, and not digest and ripen it.*

* The subject of vegetation has been considerably cultivated since the time of our author; but seems still capable of very great improvement. It were needless here to refer to the common writers upon agriculture, horticulture, and botany; few of these seem to have understood the meaning

VENERY.

It has been observed, that profuse venery dims the sight; yet eunuchs also are dim-sighted. The cause, in the former, is expense of spirits; in the latter, over-moisture of the brain, which thickens the visual spirits, and obstructs their passage, as appears by the decay of sight in age, where the diminution also of the spirits concurs as another cause. Blindness likewise proceeds from rheums and cataracts. Now in eunuchs there are all the signs of moisture, as swelling of the thighs, looseness of the belly, smoothness of the skin, &c.

The pleasure in venery is the greatest of sensible pleasures, and improperly compared to itch-

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of the foregoing enquiry, or beginning of a natural and experimental history of vegetation, with a view to the discovery of causes and axioms. Those who desire to continue the design, may do well to consult the Philosophical Transactions, the French Memoirs, the German Ephemerides, Malpighi, and Dr. Grew's Anatomy of Plants; Mr. Evelyn's Pomona, Sylva, and Terra, Boerhaave's Chemistry, and Mr. Hale's Vegetable Statics. But the plan of the whole design should be enlarged, by the addition of a set of new titles, and many new sets of experiments relating to, 1. the analysis of plants; 2. the improvement of timber; 3. the uses of fruits for making drinks and wines; 4. the best ways of treating vegetables for food, physic, c lothing, building shipping, &c. &c.

ing, though that also be pleasing to the touch. But the cause lies deep. All the organs of the senses qualify the motions of the spirits, and make so many several species of motions, and pleasures or displeasures, as there are diversities of organs. The instruments of sight, hearing, taste, and smell, are different in their make, so are the parts of generation: therefore Scaliger did well to constitute the pleasure of generation a sixth sense.* And if there were any other different organs and qualified perforations for the spirits to pass, we should have more than five senses. Perhaps some beasts and birds have senses that we have not; and the very scent of dogs is almost a sense by itself.† Again, the pleasures of the touch are greater and deeper than those of the other senses, as we find in warming upon cold, or cooling upon heat: for as the pain of touch is greater than the offences of the other senses, so are the pleasures. It is true, the affecting of the spirits immediately, and, as it were, without an organ, gives the greatest pleasure. This happens but in two things, sweet odours and wine. We see the great and sudden effect of odours in recovering

* See Jacob Thomasius de Sensu sexto, sive Titillationes Venerea.

† See Mr. Boyle upon Effluvia.

persons that faint; and it is certain, that the pleasure of drunkenness comes next to the pleasure of Venus. Great joys, likewise, make the spirits move and touch themselves, and the pleasure in venery is somewhat of the same kind.

It has been always observed, that men are more inclined to venery in the winter, and women in the summer;* for the spirits in a body more hot and dry, as those of men, are by the summer more exhaled, and in winter more condensed; but in cold and moist bodies, as those of women, the summer cherishes the spirits, and excites them; whereas the winter dulls them. To abstain or intermit the use of venery in moist and well habited bodies, breeds many diseases, particularly dangerous impostumations. The reason is evident; there being a suppression of a principal evacuation, especially of the spirits, for which there is scarce any evacuation but in venery and exercise: whence the omission of either of them causes all the diseases of repletion.† See the article *Titillation*.

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* Is this observation verified?

† The lighter part of this subject has been considered with great curiosity by certain authors, but in its grave physical part by few. A proper history of the venereal act requires a sober and careful writer, well versed in physical anatomy, the natural history of animals, and physic.

VINEGAR.

The turning of wine to vinegar is a kind of putrefaction;* and in making of vinegar, they set vessels of wine to the noon sun, which calls out the more oily spirits, and leaves the liquors sour and hard. So burnt wine is more hard and astringent than wine unburnt. It is said that cyder ripens in crossing the line, when wine or beer turns sour. Set a rundlet of verjuice to the sun in summer, as they do vinegar, to see whether it will ripen and sweeten.†

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* It may be called a real putrefaction, allowing that word to stand for a change of one body into another of very different properties; but let the common acceptation be guarded against, which denotes rather the corruption and destruction of a thing, or its becoming unfit for certain uses: this is not the philosophical sense of the word. See Boerhaave's Chemistry, in the chapter of Fermentation, vinous and acetous.

† The history of vinegar requires many curious experiments, that might open a new scene in natural philosophy: It would certainly point out an uncommon doctrine with regard to transmutations. But I know not how, it seems in a manner to be overlooked by the generality of philosophers, though it must be allowed that Glauber, Becher, and Stahl have some original experiments for disclosing its nature; and Boerhaave, in his Chemistry, has collected together many particulars from other authors relating to it. But the subject enfolds many mysteries that require a strict philosophical search, able to inform the vinegar-maker, and

All globes appear flat afar off: for distance being a secondary object of the sight, is not otherwise perceived than by more or less light, which disparity, when it cannot be discerned, all seems one, as it generally is in objects not distinctly seen. So letters, if by reason of the distance they cannot be discerned, shew but as a duskish paper, whilst all engravings and embossings appear plain at some distance.* See the article *Sound*. Sect. XX.

Both eyes move the same way; for when one eye moves to the nostril, the other moves from the nostril. The cause is motion of consent, which is strong in the spirits and spiritual parts; yet use will induce the contrary, for some can

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teach him much shorter and more profitable ways of working: for vinegar may be made from numerous cheap materials, in a very small compass of time, without depending upon the sun, which is excessively tedious, and without the use of rape, &c. And it is strange the chemists, and those who prepare large quantities of saccharum saturni, which requires a large proportion of distilled vinegar, should not be acquainted with these gainful methods. The chemists may, if they please, prepare their vinegar, for this purpose, from treacle and water, in a few days time. See the articles *Maturation* and *Sugar*.

* Consult the writers of optics upon this head, and Mr. Berkley's Dialogues of Vision.

squint when they will: and the common tradition is, that if children be set upon a table with a candle behind them, both eyes will move outwards, as affecting to see the light, and so cause squinting.*

We see more exquisitely with one eye shut, than with both,† because the vital spirits thus unite themselves the more, and become the stronger. For we may find by looking in a glass, whilst we shut one eye, that the pupil of the other dilates.

If the visual rays meet not in one angle, the eyes see double; for seeing two things, and seeing one thing twice, works the same effect, and therefore a little pellet held between two fingers laid across feels double.

Purblind men see best in a dim light, have their sight stronger near hand, and can read and write smaller than those who are not purblind; because the visual spirits, in the purblind, are

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* There seems to be truth in this common observation, insomuch that if children are placed in the cradle, where the light comes sideways, it is found to make them squint. And the cure is effected by a proper contrivance to make them look right before, that the rays of light may strike the pupilla perpendicularly.

† Do not objects to some people appear also considerably larger, when they use one eye, than when they use both? And what is the physical reason thereof?

thinner and rarer than in others, and therefore the greater light disperses them. For the same reason they need contracting; but being contracted, they are more strong than the visual spirits of ordinary eyes; as when we see through a level, the sight is stronger: so it is when we gather the eye-lids somewhat close, and it is common for those that are purblind to gather the eye-lids. But old men, when they would read, hold the paper at some distance; for the visual spirits of old men unite not, but when the object is at some distance from their eyes.*

When men look towards the sun or a candle, they see better by putting their hand a little before the eyes; for the glaring of the light weakens the eye; whereas the light diffused abroad is sufficient for vision; too much light making the eyes dazzle, and a perpetual looking against the sun would cause blindness. Again, upon coming out of a great light into the dark, and coming out of the dark into the light, men seem to

* Opticians now generally explain these matters in a mathematical manner, making the visual rays, or rays of light, to be lines; the humours of the eye, a kind of glasses; and the retina, or expansion of the optic nerve at the bottom of the eye, the seat or canvas of a miniature picture thus produced, resembling the original object. But to discover the efficient cause and manner of vision, requires a more physical search.

have a mist before their eyes, and see worse than after they have staid a little while either in the light or in the dark; for the visual spirits are, upon a sudden change, disturbed and put out of order, and, till recollected, do not perform their function well; when they are much dilated by light, they cannot contract suddenly; and when much contracted by darkness, they cannot dilate suddenly. And excess both of contraction and dilatation, if long continued, destroys the organ. For as long looking against the sun hurts the eye by dilatation, so miniature painting, and the reading of small letters hurt it by contraction.*

It has been observed, that in anger the eyes become red; and in blushing, not the eyes, but the ears, and parts behind them. The cause is, that in anger, the spirits ascend and grow brisk, which is easily seen in the eyes, that are transparent, though withal it makes both the cheeks and throat red; and in blushing, the spirits ascend to succour both the eyes and the face, which are the parts that labour; but then they are repulsed by the eyes, because the eyes in shame put back the spirits that ascend to them, as unwilling to

* But the eye is found to dilate and gradually accommodate itself to a small degree of light, or what is commonly called darkness, whence men have been able to see small objects in dark dungeons.

look abroad; for all men in that passion appear dejectedly, and this repulse from the eyes diverts the spirits and heat more to the ears and parts adjacent.*

The objects of sight, though they may cause a great pleasure, yet give no pain or great offence, unless by memory. The play of diamonds that strike the eye, indian features of curious colours, the coming into a fine garden or room richly furnished, a beautiful person, &c. greatly delight and exhilarate the spirits. The reason why the effect holds not in giving offence, is, that the sight, being the most spiritual of the senses, has no object gross enough to offend it. But the principal cause is, that there are no active objects to offend the eyes. Harmonical sounds and discords are both active and positive, so are good and bad odours, bitter and sweet tastes, too great heat and cold to the touch; but blackness and darkness are privatives, and therefore have little or no activity. However, they do somewhat sadden the mind, though very little. See the article *Senses*.

Light by refraction shews objects larger as well as coloured; for as a shilling at the bottom of water appears larger, so will a candle in a lanthorn under water. I have heard that glow-

* See the aricle *Passions*.

worms, included in glasses, are put into water, to make the fish come together; but whether a diver, having his eyes open, and swimming upon his back, sees things in the air, greater or less, I am not certain. It is manifest, when the eye is in the finer medium, and the object in the grosser, things appear larger: but when the eye is in the grosser medium, and the object in the finer, the experiment remains to be tried.*

It should be well examined whether great refractions may not be made upon reflections, as well as upon direct rays. For example, if you put a shilling into an empty bason, then go so far from the bason that you cannot see the shilling; if the bason be now filled with water, you will see the shilling out of its place. Therefore, put a looking-glass into a bason of water, and I suppose you will not see the image in a right line, or at equal angles, but on one side. Perhaps this experiment might be so extended, that one should see the image, and not the glass, which would seem strange, for then the image would appear like a phantom in the air. For example, place some strange picture over a cistern of water, so that you may not see the water; then put a looking-glass into the water; and now if you can see the picture aside, without

* See Sir Isaac Newton's Optics, passim.

seeing the water, it would appear very surprizing. They have an old tale in Oxford, that Friar Bacon walked between two steeples, which was thought to be done by glasses, whilst he walked upon the ground.*

ULCERS.

It is noted by the ancients, that in gross or impure bodies, ulcers in the legs are hard to cure, but in the head more easy: for ulcers in the legs require desiccation, which the defluxion of humours to the lower parts hinders; whereas ulcers in the head require it not. And in modern observation, the like difference has been found between Frenchmen and Englishmen, the constitution of the one being more dry, and of the other more moist: whence, a wound in the head of a Frenchman, but in the leg of an Englishman, is harder to cure.† See the articles *Swellings* and *Wounds*.

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* There are many curiosities of this kind practicable, from a commanding knowledge in optics, and the properties of glasses, variously figured, disposed, and combined. See the writers upon optics, dioptrics, and catoptrics; and consider of the proper combinations for the purpose.

† The enquiry how far the effects of climate and constitution reach in accelerating or retarding the cures of diseases, seems not duly prosecuted. Perhaps the remedies proper for a disease in one country may sometimes prove

WATER.

WATER looks blacker when moved, and whiter when at rest: because, by reason of the motion, the rays of light pass not direct, as they do when the water is at rest. Besides, splendor has a degree of whiteness, especially if there be a little repercussion: for a looking-glass with the foil behind looks larger than a bare glass.* This experiment deserves to be carried farther, in discovering by what means motion may hinder sight.†

It is a thing of great use to discover the goodness of waters. The taste, to such as drink water only, may do somewhat; but other experiments are more sure. 1. Try waters by weight, wherein you may find some difference, and account the lighter the better. 2. Try them by boiling upon an equal fire, and that which consumes fastest account the best. 3. Try them in several open vessels of equal sides, to see which

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pernicious in another, as seems to be the case of lime-water used in England and France. See Memoir. de l' Acad. An. 1700.

* Do not all bodies that reflect light strongly look larger than those that reflect it weakly? And is not this owing to the diffusive or spreading nature of light, throwing itself out every way?

† As by great velocity, unsteadiness, &c.

lasts longest without stench or corruption, and that which keeps longest unputrified account the best. 4. Try them by making drinks stronger or smaller, with the same quantity of malt, and conclude that the water which makes the stronger drink is more concocted and nourishing, though perhaps it be not so good for medicinal use; and such commonly is the water of large navigable rivers, and large and clean stagnant ponds, upon both which the sun has more power than upon fountains or small rivers. And I conceive that chalk-water is, next to these, best for going far in drink, as this also helps concoction, if drawn out of a deep well, which thus cures the rawness of the water; but chalky water, towards the top of the earth, is too fretting, as appears in the laundry, for linens washed with such waters wear out apace. 5. The good house-wives find a difference in waters for bearing or not bearing of soap: and it is likely that the fat water will bear soap best, for hungry water kills the unctuous nature of the soap. 6. Judgment may be made of waters according to the place from whence they spring or come. Rain water is by physicians esteemed the finest and best, yet it is said to putrefy soonest,* which is likely, be-

* Is that rain water apt to corrupt which has by standing deposited its sediment, not in a wooden but a clean glass or

cause of the fineness of the spirit; and in conservatories of rain water, it is not found excellent, the worse perhaps because they are covered above, and kept from the sun. Snow-water is held unwholesome, insomuch that the inhabitants at the foot of snow mountains, by drinking of snow water, have great bags under their throats. Wellwater, except it be upon chalk, or a very plentiful spring, makes meat red, which is an ill sign. Springs on the tops of high hills are the best, because they seem to have a lightness, and are more pure and unmixed, and better percolated through a great space of earth: for waters of valleys, in effect, join under ground with all waters of the same level; whereas springs on the tops of hills pass through a deal of pure earth, with less mixture of other waters. 7. Judgment may be made of waters by the soil whereon they run; as that upon pebble is the cleanest and best tasted; next, that upon clay; thirdly, that upon chalk; fourthly, that upon sand; and the worst of all is that upon mud. Nor should we trust to waters that taste sweet, for they are commonly found in rising grounds of great cities, and must needs receive much filth.*

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stone vessel, and been drawn off pure into another vessel of the same kind?

* This subject of water has been in some measure prose-

Water being contiguous to air, cools, but does not moisten it, except the water evaporates; for heat and cold have a virtual transition, without communication of substance, but moisture not; and all madefaction requires an imbibition. But where the bodies are of such different gravities as not to mix, there can follow no imbibition; whence oil lies on the top of the water, without commixture, and a drop of water running swiftly over a straw, or other smooth body, does not wet it.* See the article *Air*.

WEATHER.

It is an observation among country people, that plentiful years of haws commonly portend cold winters. They ascribe it to Providence, that reaches even to the falling of a sparrow, and much more to the preservation of birds in such seasons. The natural cause may be the want of heat and abundance of moisture in the preceding summer, which puts forth these fruits, and must needs leave a great quantity of cold vapours un-

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cuted by Mr. Boyle, and since by Dr. Hoffman in a great variety of judicious experiments. See his New Experiments and Observations upon Mineral Waters, and Dr. Boerhaave's chapter of Water, in his Chemistry.

* Is this effect wholly owing to a difference in the gravity of the bodies? See Boerhaave's chapter of menstruums.

dissipated, and thus produces the cold of the following winter.* See the article *Divination*.

WINDS.

Men's bodies are heavier and less disposed to motion when southern winds blow than when northern; for when the southern winds blow, the humours, in a manner, melt, grow fluid, and so flow into the parts, as we see in wood and other bodies, which swell with a south wind. Besides, the motion and activity of the body consist chiefly in the nerves and sinews, which relax with a southerly wind.†

WINE.

It is said they have a way of preparing their Greek wines, so as to keep them from fuming and inebriating, by adding sulphur or alum, whereof the one is unctuous, and the other astringent; and indeed those two natures best repress fumes. This experiment should be transferred to other wine and strong beer, by putting the like substances to the fermenting liquor, which may make them fume and inflame the less.‡

* See the author's History of Winds.

† See the author's history of Life and Death, and history of Winds.

‡ Does the way of correcting the Greek wines here men-

The use of wine is hurtful in dry or emaciated bodies, but in moist and full habits beneficial: for the spirits of the wine prey upon the radical moisture, as they term it of the body, and so defraud the animal spirits. But where there is moisture sufficient or superfluous, wine helps to digest and dry it up.*

WOUNDS.

It is noted by the ancients, that wounds made with brass, heal easier than those made with iron: for brass has a healing virtue, whereas iron is corrosive. It were therefore proper to have chirurgical instruments made of brass, rather than iron.†

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tioned turn upon the use of sulphur or alum in substance, or in fume, or acid spirit? The use of burning brimstone in the way of match, as the wine-coopers call it, is common, and of very extraordinary efficacy, though overlooked by philosophers. And the beneficial use of the acid spirit of sulphur or alum is a secret in wines that lies in few hands. The natural and experimental history of wines is greatly wanted, as well for the improvement of philosophy as the service of ordinary life. See the article *Sugar*.

* There is wanting a solid account of the virtues and uses of wines, to be drawn from experience and observation, without indulging levities, or running out into encomium or invective.

† Is the ancient observation just, upon which this direction is founded? For the medicinal virtues of the several metals, see Boerhaave's Chemistry, under the processes upon Metals.

It is observed, that a sheep-skin newly pulled off, or whites of eggs applied to wounds, will keep them from swelling or exulcerating, and heal them. The cause is a temperate conglutination; for both these bodies are viscous, and restrain the flux of humours to the part, without penning them in.* See the articles *Swellings* and *Ulcers*.

YAWNING.

It has been noted dangerous to pick the ear whilst one yawns; for in yawning, the inner part of the ear is extended, by drawing in the breath, as both in yawning and sighing, the breath is first strongly drawn in, and then strongly expelled.†

* The method of curing wounds by the first intention has not been diligently prosecuted, but rather meets with opposition.

† Let a nearer approximation be made to the cause, if the fact be sufficiently verified.

THE END.

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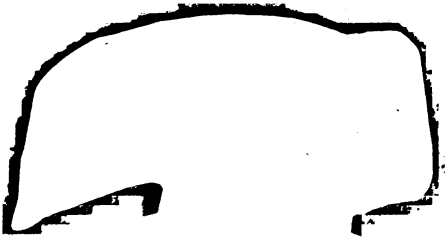
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